EFFECTS OF VISUAL FIELD LOSS ON STANDING BALANCE

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INTRODUCTION

Falls are a significant health concern in older adults. Around 1 out of 3 adults older than 65 years falls every year [1]. Falls can lead to physical and psychological health problems in the elderly [2]. Falls and fall-related injuries also account for a significant portion of health care costs [3]. Vision is one of many important factors that influence balance. As a result of this link, vision impairment causes an increased risk of falls [4].

Visual field loss is the most significant form of vision impairment when it comes to increased fall risk [4]. Two of the leading causes of visual field loss are glaucoma and age-related macular degeneration (AMD), both of which have been shown to negatively impact balance and increase fall risk [5,6]. Glaucoma and AMD affect different areas of the eye and therefore cause different visual field losses, glaucoma affecting peripheral vision and AMD affecting central vision.

Previous research into the effects of glaucoma and AMD on standing balance has only compared the balance of subjects with the diseases to other subjects with healthy vision. This does not allow for intra-subject comparisons and limits the ability of the researcher to determine whether the visual field loss is responsible for the diminished balance or if it is a result of other disease factors. This study improved upon this method by using specially designed contacts that can selectively occlude either central or peripheral vision[7]. These contacts allow for intra-subject comparison and for more control in the study of visual field loss.

OBJECTIVE

The objective of this study was to determine the effects of central and peripheral visual field losses on standing balance. An intra-subject comparison will be done to compare the effects of the different visual field losses.

HYPOTHESIS/SUCCESS CRITERIA

The hypothesis for this study is that peripheral visual field loss will have a greater negative impact on a person’s balance than central visual field loss. The negative impact will be greater when other sensory inputs are unreliable.

METHODS

Eight young subjects (age 25-35, 5 females) and three older subjects (age 75-85, 1 female) all with healthy vision were recruited. Individuals with conditions affecting gait or balance were ineligible for the study. The protocol was approved by the Institutional Review Board and subjects signed a consent form prior to testing. Subjects were first screened for visual and vestibular conditions and excluded if screenings were not normal. Balance data was collected using an Equitest posture platform. The posture platform allows for sway-referencing of the floor and the visual scene. The floor has a force plate used to measure the center of foot pressure (COP). Two pairs of specially designed contacts were ordered for each subject. The first pair had a 8-mm diameter black circle painted in the middle to block the central visual field but not affect peripheral vision. The second pair had a black ring painted with a 1.5-mm clear pupil to block peripheral vision but not affect central vision. There were 6 trials completed for both lens conditions and a baseline test with no contact lenses for a total of 18 trials per subject. The different trial conditions are shown in Table 1.

Table 1: SOT trial descriptions including eye, vision and proprioception conditions.

<table>
<thead>
<tr>
<th>Trial</th>
<th>Eyes</th>
<th>Vision</th>
<th>Proprioception</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Open</td>
<td>Fixed</td>
<td>Fixed</td>
</tr>
<tr>
<td>2</td>
<td>Closed</td>
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<td>Fixed</td>
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<tr>
<td>3</td>
<td>Open</td>
<td>Sway</td>
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<td>Sway</td>
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<tr>
<td>5</td>
<td>Closed</td>
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<td>Sway</td>
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<tr>
<td>6</td>
<td>Open</td>
<td>Sway</td>
<td>Sway</td>
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COP data was processed with a low-pass Butterworth filter (Fc=2.5 Hz). The first and last five seconds were removed to remove any transient effects. The data was resampled from 100 Hz to 20 Hz. The root mean square (RMS) of the processed COP data was calculated. The velocity of the COP was obtained from the processed COP data. The mean velocity (MV) was calculated from the velocity data. RMS and MV values were normalized to the baseline test for each trial. As a result of the normalization, all baseline values for RMS and MV were 1. For a normalized RMS or MV of 2 then that means the actual RMS or MV was 2 times the baseline RMS or MV. This type of normalization is done to emphasize the effects of the contact lenses relative to baseline.

A mixed linear regression model was used to analyze the data, with the outcome variable of interest being RMS or MV. The independent fixed factors included in the model included age group and the occlusion condition (baseline, central, peripheral). Subject was included as an independent random effect. Statistical significance was set at 0.05.

RESULTS

The RMS data was not a good indicator for the effects of visual field loss on balance during our study. Lens type did not show a statistically significant effect on the RMS values during any of the SOT trials.

Mean velocity was a better indicator for the effects of visual field loss on balance. Lens type had a statistically significant effect during trial 1 and trial 4 of the SOT. During trial 1 the average normalized mean velocity was greater for the central occlusion lenses, with a value of 1.20, than baseline
with no contacts, with a value of 1.00 (Figure 1). Peripheral occlusion had a normalized MV value of 1.12 and did not reach statistical significance for this trial.

![Normalized Mean Velocity Results](Figure 1)

**Figure 1.** SOT trial 1 normalized mean velocity results averaged across all subjects. Standard deviation bars are presented.

During trial 4 the average normalized MV for both the central occlusion and peripheral occlusion lenses was greater than baseline. Central occlusion had an average normalized MV of 1.33, peripheral occlusion had a value of 1.38, and baseline again was 1.00 (Figure 2).

![Normalized Mean Velocity Results](Figure 2)

**Figure 2.** SOT trial 4 normalized mean velocity results averaged across all subjects. Standard deviation bars are presented.

**DISCUSSION**

The results of this study do not support the hypothesis that peripheral visual field loss is a larger detriment to balance than central visual field loss. The results show very similar effects of central and peripheral visual field losses during trial 4 of the SOT. In fact our results show that the central occlusion lenses actually had a more detrimental effect on balance during the first SOT trial. The reason this may be occurring is that, when using the central occlusion lenses, the peripheral vision may be affected slightly and therefore becomes unreliable. The effects of having unreliable peripheral vision may actually be worse than having no peripheral vision at all. The body may think that it is receiving reliable peripheral visual field information and therefore act according to faulty information. When the peripheral vision is completely removed the body will not rely on the peripheral vision information and therefore may be able to balance more effectively.

The negative impact of the visual field losses was greater when other sensory inputs were unreliable, which is in agreement with our hypothesis. However, the results were a little different than expected. The expectation was that the greatest effects on balance would be seen during trial 6 of the SOT. This test provides unreliable vision and proprioception so it was expected that this test would be the most difficult and show the most effect of the contact lenses. In reality, trial 4 of the SOT showed the most dramatic effect of the contact lenses. This trend does make sense because trial 4 provides unreliable proprioception but leaves vision unaffected. Thus, the subject must rely on their vision more during this trial. As a result of relying on the visual system more, having visual field losses during this trial causes a greater negative effect on balance.

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**REFERENCES**