INTRODUCTION

Vision impairments are among the leading risk factors for falls and falls-related injuries. While epidemiological studies have linked visual dysfunction with poor balance and falls, to date, the effect of visual field loss alone has not been investigated. Studies describing the effects of visual field loss in actual patients can be confounded by the presence of systemic or ocular co-morbidities, which can make it impossible to tease out the effects of visual field loss alone. This is particularly true in the case of balance or gait studies in which conditions such as arthritis or knee replacement surgery, common in the older adults, can confuse results. In order to eliminate the potential confounders of non-ocular and ocular co-morbid conditions, we developed a method of inducing visual field loss by using painted contact lenses in otherwise completely normal subjects to isolate the effect of visual field loss alone. This method provides a tool to selectively mimic visual field impairments in the absence of co-existent ocular or systemic co-morbidities that could confound balance testing. A full description of this lens model is described elsewhere [1]. Briefly, a central visual field occlusion is created by application of a soft contact lens that has been painted with an 8mm central opacity. Similarly, circumferential peripheral occlusion is elicited by application of a soft contact lens that is painted black with a clear, 1mm central aperture.

Prior studies have largely failed to elucidate underlying mechanisms explaining how specific visual impairments result in postural instability. The goal of this preliminary study was to determine the impact of restricted central or peripheral visual field losses alone on one specific mechanism for postural instability, namely the ability to integrate sensory information important for balance.

METHODS

Six healthy young adults (mean 23, std. 3) with no balance/mobility impairments were recruited for participation in this study. Subjects were given a comprehensive ocular examination and baseline visual field test prior to the balance testing, which occurred at a subsequent visit. Both the central and peripheral occlusion lenses were worn bilaterally and a control condition without lenses was administered. All subjects wore their habitual spectacle correction over their contact lenses while performing the balance protocols.

The balance protocol consisted of the standard Sensory Organization Test (SOT) [2] conditions 1-6: Condition 1: Eyes open and fixed visual scene (Fixed-Vis)/fixed floor (Fixed); Condition 2: Eyes closed/Fixed; Condition 3: Sway referenced visual scene (SR-Vis)/Fixed; Condition 4: Fixed-Vis/sway referenced floor (SR-F); Condition 5: Eyes closed/SR-F; and Condition 6: SR-Vis/SR-F. The lens conditions were: (1) none, (2) peripheral vision occluded, and (3) central vision occluded. Each SOT condition (60s in duration) was repeated three times, once for each lens condition.

Sway amplitude and velocity were quantified using two variables: root mean square (RMS) of the anterior-posterior COP time series, and mean velocity (MV) [3]. Data from SOT conditions 2 and 5 were not included in the analysis as the eyes are closed in these conditions. A repeated measures ANOVA model was used for the analysis of the data.

RESULTS AND DISCUSSION

The lens conditions were found to have a significant effect on the velocity of sway (MV), but not on the magnitude of sway (RMS). The analysis revealed a
statistically significant main effect of lens condition ($F=4.15; p=0.049$), floor condition ($F=92.4; p<0.0001$), and visual scene condition ($F=11.1; p=0.02$) on MV. In addition, there were significant interaction effects on MV, including a floor condition x visual scene condition ($F=9.03; p=0.03$) and lens condition x floor condition x visual scene condition ($F=6.19; p=0.02$). Thus, the impact of the lens condition was influenced by the postural conditions (Fig. 1). More specifically, when correct proprioceptive information was available (fixed floor condition) there was no impact of lens condition on MV. However, when proprioceptive information was incorrect (sway referenced floor) MV was increased with peripheral visual field occlusion compared to central visual field occlusion and to the baseline of no lens condition (Fig. 1a). During the sway referenced visual scene conditions, occluding central vision reduced MV sway and there was no effect of occluding peripheral vision compared to baseline (Fig. 1b).

Figure 1. Impact of lens condition on mean velocity (MV) in two somatosensory conditions: Fixed (fixed floor) and SR-F (sway referenced floor).

Our results suggest that peripheral visual inputs influence postural control to a greater extent than central vision in healthy subjects. More specifically, occluding the peripheral visual field increased sway velocity, particularly when the somatosensory information was unreliable. Occluding central vision did not impact standing balance, compared to having a full visual field available. These findings occurred when visual inputs were available/reliable (fixed visual scene). However, when visual information was unreliable (sway-referenced visual scene), occluding peripheral vision did not impact sway velocity, but occluding central vision reduced velocity. Only sway velocity (and not the RMS of sway) was affected by the visual field inputs, suggesting that in healthy adults peripheral vision does not impact the magnitude of sway; however, absence of peripheral vision poses a greater challenge for the postural control system, requiring more effort to maintain balance.

Caution should be exercised if comparing the results obtained in our healthy young subjects wearing contact lenses to an aged cohort. Aging effects such as cognitive decline or motor deficiencies cannot be controlled unless the subjects are age-matched. In addition, it is known that sensory integration for postural control changes as a function of age, with vision and proprioception becoming more important as vestibular function declines. Thus, one would anticipate that the effects in older adults would be even greater as sensory integration processes change. Future studies are planned to compare young and older subjects wearing the contact lenses to investigate the influence of age on the visual field loss and balance.

REFERENCES


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