Training with Brief Visual Occlusions Improves Balance Control in Treadmill Beam Walking

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1 Introduction

Falls are a major health concern amongst multiple populations. Individuals with sensorimotor or musculoskeletal deficits, such as spinal cord injury or lower limb amputation, fall at greater rates than physically intact individuals. Falls are also prominent in the elderly, and can have substantial socio-economic consequences. There is a great need to identify better balance training protocols that are simple enough to be performed at home and lead to reductions in falls.

Many balance training interventions have focused on the use of visual, proprioceptive, or vestibular perturbations [1]–[4]. Visual perturbations may be the easiest to enact without complicated equipment and vision is especially important when walking on a narrow surface or acquiring a new motor skill [5]. A past study in our lab showed that participants training while wearing a virtual reality headset improved their balance performance four times as much when they experienced visual rotations compared to participants training without visual rotations [3]. High-density electroencephalography data revealed that the visual rotations produced a strong response in the posterior parietal cortex during training. The rotation caused a strong synchronization in theta and alpha frequency bands, followed by a strong desynchronization in the beta frequency band. It is possible this stimulation of the posterior parietal cortex caused by the visual rotation led to the enhanced motor learning gains in balance control. Virtual reality headsets are, however, bulky, expensive, and induce motion sickness.

In our current study we used occlusion glasses (Senaptec, Oregon, USA) to introduce transient visual perturbations while participants walked on a balance beam. The glasses had the ability to change from clear to opaque, restricting the participant's vision. We hypothesized that training participants with brief visual occlusions would lead to an increase in balance performance compared to training participants with unperturbed vision. We also wanted to see if this effect would be retained two weeks after the initial training.

2 Methods

2.1 The Task

Twenty healthy young adults were randomly assigned to one of two training protocols: a) training with visual occlusions (6 female, 4 male), b) training with unperturbed vision (5 female, 5 male). The visual occlusions group was presented with periodic 1.5 second visual occlusions followed by 7.5 seconds of clear vision. The unperturbed vision group performed the training retaining their full vision at all times. The training took place on a treadmill-mounted beam that was 2.5 cm high and 2.5 cm wide (Figure 1).

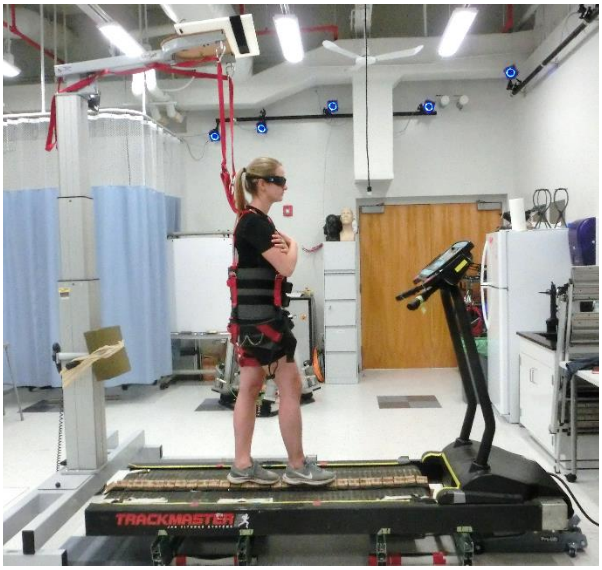

Figure 1: Participant walking on the treadmill-mounted balance beam while wearing the occlusion glasses.

To evaluate changes in performance, participants performed 3-minute pre-, post- and retention tests. During these tests, subjects walked on the beam without any visual perturbations. The post-test took place on the same day as the training. The retention test took place two weeks later.

2.2 Data analysis and statistics

We evaluated performance by counting the number of step-offs per minute: the number of times the participant stepped off the beam divided by the time they spent on the beam. We quantified balance improvement as the difference between the pre-test and post-test performance (same day), and the difference between the pre-test and retention test performance (two weeks later). To normalize across different subject skill levels, we divided the balance improvement metrics by the pre-test performance.

We performed a repeated measures ANOVA with the training protocol (visual occlusions, unperturbed vision) as the between-subjects variable and the testing day (same day, two weeks later) as the within-subjects variable. We also performed independent t-tests between the two groups for each day, to evaluate performance differences for both time points.

3 Results

Training with brief intermittent occlusions had a significant effect on balance improvement compared to training without occlusions ($F_{(1,18)}$=7.2, p<0.05). The visual occlusions group showed a four times higher improvement compared to the unperturbed vision group on the same day ($t_{(18)}$=-2.95, p<0.01) (Figure 2). The visual occlusions group retained the majority of the training effect two weeks later, showing 49% performance improvement. The control group that trained without occlusions showed no retention of the training improvement.

4 Discussion

Training participants with brief intermittent occlusions while walking on a treadmill-mounted beam, resulted in a 78% balance improvement on the training day. The improvement was four times higher compared to that of the unperturbed vision group. Similar results were observed in a previous study from our lab were participants showed transient balance improvements when exposed to brief visual rotations [3].

Results from the current study also found that the balance improvement for the visual occlusion group was mostly retained two weeks later. The subjects with visual occlusion training had a reduction in falls over the beam by 49% after two weeks. This finding suggests that there are long term motor leaning effects from training with brief, intermittent visual occlusions.

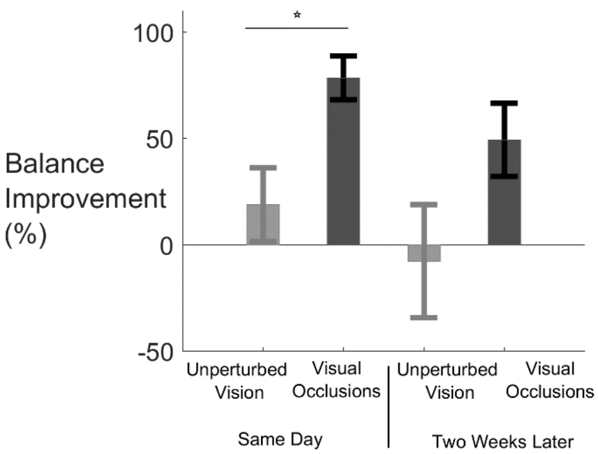

Figure 2: Balance improvement for the unperturbed vision group and the visual occlusions group measured on the same day and two weeks after the training. Training with the brief, intermittent visual occlusions substantially boosted the training effect of beam walking practice.

In a subsequent experiment, we are quantifying electrocortical changes that occur with the visual occlusion. In the previous study, visual rotations resulted in activation of occipital and posterior parietal areas, with a pattern of alpha/theta synchronization and beta desynchronization following the rotation onset and offset [3].

It seems reasonable to propose that the brief, intermittent visual occlusion also produced a similar stimulation of the occipital and posterior parietal cortex. The parietal cortex plays a key role in cross modal integration. It receives and enhances information from different modalities relevant to a task. It has already been shown in macaque monkeys that changing the content of visual information can induce reweighting of different sensory modalities [6]. It is possible that introducing visual perturbations shifted the weighting from the visual to the proprioceptive and vestibular channels, resulting in performance enhancement and long-term motor learning. Understanding the underlying neurophysiological responses caused by visual perturbations should help design better training paradigms.

This study only included healthy young adults that were physically intact. Based on the current results, it would seem reasonable that testing patient and elderly populations might also reveal enhanced balance training effects with visual occlusion.

5 Conclusions

Brief, intermittent visual occlusions during beam walking training led to long-term balance improvements. This novel training protocol is simple and easy to perform. Future research on individuals with sensorimotor and physical disabilities is warranted.

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