International Journal of EXERCISE SCIENCE

Original Research

The Effect of Stroboscopic Vision Training on Blind-folded Straight-line Walking

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ABSTRACT

International Journal of Exercise Science 17(1): 438-444, 2024. Stroboscopic vision training has shown to improve visual-motor control and dynamic visual acuity in sport performance; however, no studies have considered using this training to enhance kinesthetic awareness during walking, applicable to high fall-risk populations. Purpose: The purpose of this study was to assess the effect of stroboscopic vision training on blind-folded straight-line walking. Methods: Thirty-seven college-aged healthy participants (age: 20.14 ± 1.23 years; females: N = 32, males: N = 5) completed this study. In this pre-posttest quasi-experimental investigation, participants with no epileptic or balance disorder history completed a four-week progressive stroboscopic vision training protocol. To assess sensorimotor feedback participants were instructed to walk a 27.5 m straight line while blindfolded. PRE and POST blind-folded straight line walk tests were completed and deviations from endpoint were measured. A paired-samples *t-test* was used to analyze the calculated deviation angles. Results: Significant difference was noted from PRE (14.48 ± 5.95) to POST (11.60 ± 6.78) deviation angles ($t(36) = 2.71$, $p = 0.01$). Conclusions: This is the first study to examine the effects of stroboscopic training on a vision restricted walking task, which demands feedback re-weighting. These findings may be valuable for clinical settings or performance where reliance on non-visual systems may be beneficial.

KEY WORDS: Sensorimotor, feedback re-weighting, proprioception, postural coordination

INTRODUCTION

Closed-loop feedback from proprioceptive, visual, and vestibular systems provide information to maintain stability and postural control during locomotion (14). Specifically, the visual system provides essential cues to augment walking and sport performance in clinical (8) and healthy populations (1, 12). Manipulation of one or more sensorimotor systems redirects the central nervous system to rely on the information provided to maintain coordination, also known as "sensory re-weighting" (4, 15). For instance, by disrupting vision, greater reliance is applied to somatosensory and vestibular feedback for task execution. Previous research has used vision training to enhance visual-motor control (3) and dynamic visual acuity (11), with downstream translation to drills or competition (8, 12). Thus, by training with limited visual feedback, performance during often encountered suboptimal conditions or when vision is ideal, the re-introduced stimuli may cause greater sensitivity resulting in better outcomes (1). This concept is the foundation of stroboscopic devices, which allow for intermittent perturbations to the visual system (1, 10).

Previous research using stroboscopic eyewear has reported improved vision (3), attention (2), anticipatory timing (18), sport performance (12), and motion sickness (16) after training. As previously mentioned, the vision occlusion training, which may even result in immediate performance benefits (18), re-weights the reliance on other sensory input for later outcome improvements. For example, when a football receiver or baseball outfielder is running to catch a ball, they often cannot rely merely on vision to estimate the destination of the ball. Therefore, contribution of kinesthetic and vestibular senses adapt for optimal performance in the environment or suboptimal condition. Although much of the previous applicable research has focused on visual acuity to enhance feedforward and re-weighted feedback control during sport performance, another important avenue that has been recently investigated is how stroboscopic vision training may benefit rehabilitation and injury prevention.

Swanik and colleagues (19) examined neurocognitive control of collegiate athletes who sustained a non-contact anterior cruciate ligament (ACL) injury, and found that these athletes had slower reaction times, processing speeds, and worse visual memory that may have increased the chance of their injuries. Therefore, stroboscopic training may help mitigate risk of injuries from interrupted sensorimotor feedback (9). Furthermore, primary ACL injury may result in greater reliance on the visual system for postural stability and as a compensatory mechanism due to alterations in neuromuscular control post-injury; however, with stroboscopic training, a patient may prevent re-injury in future suboptimal conditions by shifting the increased visual dependence to the somatosensory and/or vestibular systems (9). Another study examined the effects of visual perturbations using eyes-opened, stroboscopic vision, and eyes-closed conditions to test balance, and noted increased postural stability with more visual input (10).

Although previous research has revealed important use for stroboscopic training in the scope of vision acuity and visual-motor enhancements, no studies to our knowledge have considered the effect of progressive vision occlusion training on normal daily task performance. The value of enhanced vision restricted walk training applies specifically to fall-risk-prone population. By enhancing straight-line walking during restricted vision, tasks that require accurate proprioception in suboptimal conditions (i.e. night-time walking or walking without appropriate corrective eyewear) may become easier for at-risk populations. Therefore, the primary purpose of this study was to assess the effect of stroboscopic vision training on blind-folded straight-line walking. This pilot study was done to assess proprioception and postural coordination without visual cues during an instructed dynamic task to further understand CNS re-weighting after random, but progressive stroboscopic training and will add to the potential clinical use of this technology. We hypothesized that stroboscopic training would enhance blind-folded straight-line walking in young adults.

METHODS

Participants

Thirty-seven healthy college aged participants (age: 20.14 ± 1.23; females: $N = 32$, males: $N = 5$) completed this study. Sixteen participants reported having corrected vision, and two were left-hand dominant. Participants were not enrolled if they had history of epilepsy or balance disorders. Participants were not asked to refrain from routine activities through the course of this study. Mississippi State University's Institutional Review approved all testing procedures prior to this pre-posttest quasi-experimental design study. All participants completed the same protocol between pre- and post-testing.

This research was carried out fully in accordance with the ethical standards of the International Journal of Exercise Science (13).

Protocol

During the initial visit of the study, participants provided written informed consent, and completed baseline testing of three blind-folded straight-line walk tests (Figure 1). Prior to blind-folding the participants, they were instructed to begin walking at the sound of an auditory stimulus and walk in a straight line to the designated endpoint 27.5 m away, when they heard "And, Stop." Once blind-folded, participants were guided along a non-linear route by a researcher to the starting position. Without blind-fold removal, participants were guided back to the starting position for the consecutive trials. Researchers remained at set positions across the path to assure safety of each participant as visual deprivation introduced gait instability (17). Endpoint deviations were marked at the end of each trial and measured (Tekton 7230, Grand Rapids, MI, USA) once all trials were complete. Once baseline trials were completed, participants were fitted with the Nike's SPARQ Vapor Strobe® Eyewear (Nike Inc., Beaverton, OR, USA) to test comfort. Participants completed a four-week progressive vision restriction stroboscopic training and reported back for post testing identical to the pretest.

Vision Training: Participants reported to the training facility twice per week on non-consecutive days for four weeks. The eyewear, which uses liquid crystal lenses, flashed between clear (constant at 100 ms, 1-6 Hz) and opaque (variable from 67 to 900 ms, increasing time in opaque vision per setting). Strobe lenses were set to the appropriate setting prior to each session. During each session, participants wore the eyewear for a 30-min bout and walked un-uniformly around the gymnasium with a researcher. Participants returned the eyewear at the end of each session. This was repeated for each session until the end of the protocol.

Statistical Analysis

Data are presented as mean ± standard deviation. Deviation angles were calculated based on measured deviations from endpoint. Data was analyzed using IBM SPSS V25.0 (IMB Corporation, Armonk, NY, USA). Paired samples t-test was conducted to compare PRE versus POST deviations with significance level of $p < 0.05$. Effect size was calculated using Cohen's D.

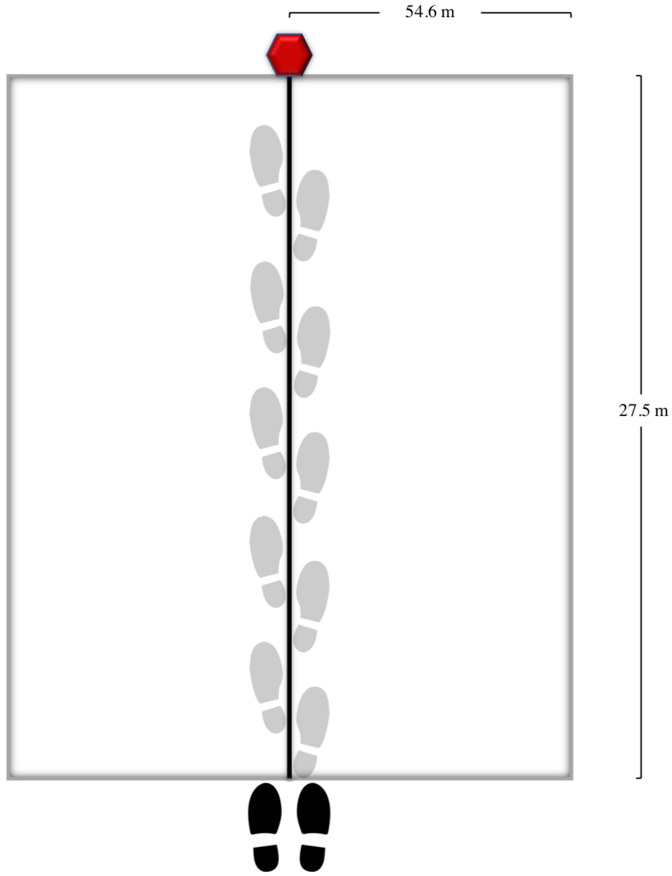

Figure 1. Straight-line walk task.

RESULTS

Four participants missed one training session (three missed one session at setting 4, and one missed one session at setting 6, and the remaining 33 participants completed all 8 sessions.

Significant difference was noted from PRE (14.48 ± 5.95) to POST (11.60 ± 6.78) deviation angles ($t(36) = 2.71$, $p = 0.01$, ES = 0.45) (Figure 2).

DISCUSSION

The results of this study suggest progressive stroboscopic vision training improves vision restricted walking in young adults (Figure 1). Training for this study included eight 30-min sessions of random walking with stroboscopic eyewear. The protocol included a progressive increase in occluded vision time; participants trained twice in the same setting before training in the next setting. Previous research suggests improvements from stroboscopic vision training may be specified to the respective activities practiced during the training, such as training in hockey players (12) or sensorimotor drills in softball players (1). Stroboscopic vision training has also been shown to improve short term memory (2), central visual field motion and transient attention (3) after unspecified training tasks, such as playing catch. The current study explored mixed perspectives of the aforementioned studies. Participants trained with a random walking task, where they navigated around a room while maintaining coordination and stability using more proprioceptive and vestibular senses as their vision was increasingly disrupted. The final objective was to walk in a straight line, blind-folded. Deviations from the task were measured and based on the average decreased deviation from midline noted post-training (Figure 1), we can infer generalized stroboscopic training may improve somatosensory and vestibular skills when visual cues are restricted.

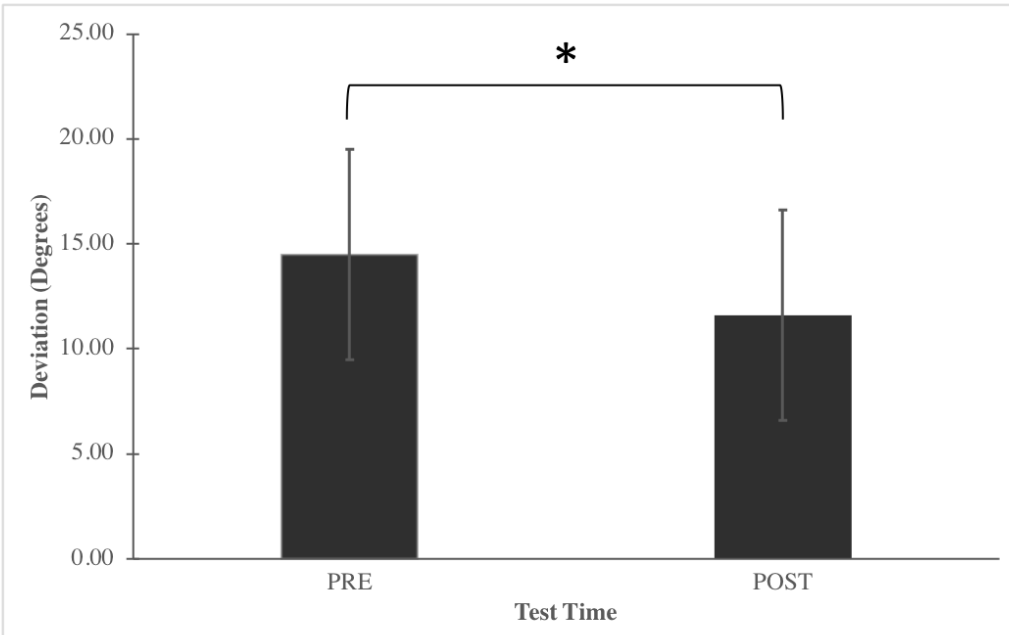

Figure 2. Effect of progressive stroboscopic vision training measured by PRE to POST angle deviations from endpoint. * Denotes significant difference from PRE. Data is represented as mean ± SD.

Although many studies have focused on the visual acuity (11) and performance benefits (12) from stroboscopic vision training, this study's findings may be translated to a clinical setting, as well. With generalized stroboscopic training twice per week for 30-min bouts, our results suggest individuals improve their vestibular and kinesthetic sense for straight-line walking. For instance, if an older adult wakes up in the middle of the night needing something from across the room and has been training with the stroboscopic eyewear, they may be more inclined to maintain their balance and coordination while walking to the other side of the room through adaptations resulting from vision occlusion training. This sensory feedback redistribution may help prevent falls, the leading cause of death in older adults (5), secondary to increased proprioceptive control. Thus, like previous studies, this training tool may be used to assess and train balance (10), which may be especially beneficial for anyone who is prescribed corrected eyewear (i.e. glasses or contact lenses) but is not wearing them at a given moment. Future studies may further explore the findings from the current pilot work to decipher the extent of re-weighting to the available sensory systems mentioned above.

There were notable limitations to this study. First, without a matched control group, we are unable to definitively state whether the improvements shown from pre- to post- tests were solely from the vision occlusion training. However, the effect size is noteworthy, and further research should explore the effects of progressive stroboscopic training on vision restricted tasks. Second, participants were not asked to refrain from daily routines. If some participants trained in balance or coordination parameters, this may have altered their posttest performance. Additionally, handedness or gender were not matched; therefore, this study laid groundwork for other studies to examine significant gender or handedness differences for stroboscopic training on vision-restricted tasks such as straight-line walking.

To our knowledge, this is the first study to investigate the effects of stroboscopic training on an occluded vision task. Given the decreased deviation noted from pre to post training, the use of stroboscopic eyewear twice per week for 30-min bouts can be considered a way to improve proprioceptive and vestibular re-weighting with limited visual cues. Therefore, this study not only supports previous research suggesting the benefits of this easily transportable stroboscopic eyewear technology, it also provides a new scope of application for this device. Future research should use similar training in a higher-risk population or those living with impairment to further understand potential benefits of this training mechanism.

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