Article ▸ The Effectiveness of Electronic Multisensory Devices vs. Classic Optometric Vision Therapy Procedures

Lyndsey Ferris, OD, Sheppard AFB, Texas
Sarah Hebert, OD, Grand Rapids, Michigan
Jennifer Simon, OD, Grand Rapids, Michigan
Daniel Wrubel, OD, Ferris State University, Michigan College of Optometry, Big Rapids, Michigan

ABSTRACT

Introduction: The purpose of this paper is to determine the effectiveness of using multisensory gaming devices (such as the Nintendo Wii) in comparison to more traditional therapeutic techniques (i.e., Wayne Saccadic Fixator (WSF), major rotator) for the treatment of oculomotor dysfunction.

Methods: Thirty-eight subjects were equally divided into control (1) and experimental (2) groups and underwent similar optometric vision therapy procedures using either the WSF and rotators or Nintendo Wii Sports and Guitar Hero. Data was collected over ten visits (baseline, eight vision therapy sessions, and final evaluation). The subjects' baseline and final oculomotor skills were assessed with both the Developmental Eye Movement (DEM) test and the Visagraph.

Results: Oculomotor skills of both groups showed statistically significant improvement. DEM mean horizontal reading time improved for group 1 (28.20 to 25.43 seconds, p=0.002) and group 2 (28.53 to 24.89 seconds, p<0.001) while DEM ratios revealed statistically significant improvement for group 2 (1.05 ±0.10, p=0.003). Bland-Altman analysis revealed a greater mean increased average difference in the adjusted horizontal DEM scores for group 2 (3.8) than group 1 (2.4). While not statistically significant, Visagraph analysis did show an increase in grade level efficiency for group 1 (11.36 ± 3.41 to 11.88 ± 2.39, p=0.489) and an increase in both average reading speed (284.95 ± 83.30 WPM to 304.11 ± 100.99 WPM, p=0.452) and grade level efficiency (11.83 ± 3.12 to 12.10 ± 2.97 grade level, p=0.772) for group 2.

Conclusion: This study suggests that multisensory gaming devices such as the Nintendo Wii are viable options for the treatment of oculomotor skills in place of, or in conjunction with, traditional oculomotor vision therapy.

Keywords: computers, Developmental Eye Movement test, Nintendo Wii, oculomotor dysfunction, Visagraph, vision therapy

Introduction

Eighty percent of all learning is through the visual system.[1] In order for learning to be efficient, many components of the visual system need to work in unison. When they do, the system is capable of decoding letter and word images from visual space for the interpretation of written information in conjunction with language-based aspects of reading. When the system is dysfunctional, an individual may struggle with even the simplest reading tasks.

Important parts of the visual system include the basic skills of saccades, pursuits, and fixations, which function for tracking and scanning. Combined, these skills are better known as oculomotor skills. Oculomotor dysfunction can lead to inefficiency of the visual system, whereby individuals may experience a decrease in reading speed, reading or scanning efficiency, attention, and/or comprehension, as well as an increase in errors during visual tasks.[2]

Optometric vision therapy manages and enhances the visual system to function at its fullest potential. The vision therapy program is individualized based upon both the practitioner and patient goals. Whatever the treatment plan, vision therapy typically involves office-based therapeutic tasks, in addition to supplementary home-based procedures. Prisms, loose lenses, anaglyphic glasses, occluders, filters, and computer programs are just a few of the tools used by eye care providers for vision therapy.[3,4]

More specifically, the use of the Wayne Saccadic Fixator (WSF) and major rotators has long been part of the standard treatment for oculomotor dysfunction.[2,3] These devices integrate visual, auditory, and motor components that aid in developing fixation, saccadic, and pursuit skills.

Electronic multi-sensory gaming devices such as the Nintendo Wii also integrate these skills. The Nintendo Wii has already found a niche with numerous physical therapy and rehabilitation programs worldwide. It has been used for physical fitness and balance training in nursing homes, as well as for stroke rehabilitation and patients with cerebral palsy.[5-7]

Researchers have begun to analyze the effects of gaming systems on the visual system. One study found a positive impact on contrast sensitivity with gaming.[8] Another correlated visual attention and processing skills to the use of video games.[9] The purpose of this study was to determine

Table 1: Inclusion Criteria for Vision

• Monocular VA ≤ 20/30
• Local stereopsis ≤ 40 seconds of arc
• Negative history of strabismus

whether Nintendo's Wii gaming system would be useful in vision therapy programs, specifically to help treat oculomotor dysfunction.

Results were measured using the Developmental Eye Movement Test (DEM) and the Visagraph III Eye Movement recording system. The DEM measures saccadic movements by having patients read through a series of numbers as quickly as possible. Vertical and horizontal speeds are documented, adjusted for errors, and then calculated into a ratio.[10] The Visagraph records eye movements while subjects read a paragraph. The computer-based system tracks fixations, average duration of fixations, regressions, and number of saccades. Words per minute reading speeds, estimated grade level efficiencies, and overall comprehension of the reading material are calculated.[10]

Scheiman et al.[11] and Rouse[12] found the Visagraph to provide the most reliable method for clinical recording of eye movements. In addition, Visagraph reading rate has been found to relate closely to both DEM horizontal adjusted reading rate and the DEM ratio. Webber et al. found the vertical and horizontal speeds to be useful in objective measurements of eye movements, while recent studies indicate that the DEM correlates more closely with visual processing and reading performance than saccadic eye movements.[10,13]

Methods

This study was approved by the Human Subjects Research Committee at Ferris State University. Undergraduate Honors students were recruited for participation in the study. Subjects were encouraged to participate on a volunteer basis, with an incentive to receive community service hours that are a requirement for Honors Program students.

A vision screening was conducted to assess visual skills for participation in the study. The screening included Snellen distance and near monocular acuities, distance and near cover testing for binocular posture, and Wirt stereopsis. The DEM and the Visagraph were also administered to establish baseline data and for final analysis at the conclusion of the study.

Inclusion criteria required a minimum age of 18 years, best corrected monocular acuities of 20/30 or better, and binocular stereopsis of at least 40 arc seconds (Table 1). Participants with a history of strabismus, brain injury, seizure, major surgery, and/or debilitating symptoms were excluded from the study. Of thirty-nine subjects tested, thirty-eight met the inclusion criteria. Each subject was assigned a subject number at random for identification purposes. Participant identifying information was never revealed to examiners involved in data collection or interpretation.

Subjects were divided equally and at random into two groups: control and experimental. The control group (Group 1) was assigned vision therapy using traditional WSF and rotator procedures. The experimental group (Group 2) underwent vision therapy using the Nintendo Wii Sports and Guitar Hero procedures. Subjects from both groups attended eight sessions of therapy, each lasting twenty minutes in duration, over the course of four weeks. Vision therapy was held simultaneously for both groups in isolated and separate areas of the same building. Supervision responsibilities were rotated between the two groups throughout the duration of the study.

During week one, subjects were acquainted with either the Nintendo Wii games or the WSF and rotators. Examiners instructed the subjects on how to use each instrument. Therapy for Group 1 consisted of five minutes of therapy per eye using a random target selection program on WSF and five minutes of therapy per eye inserting and removing pegs to form pre-determined shapes (square, triangle, star) on the pegboard rotator. Group 2 completed five minutes of therapy per eye using Wii Sports baseball and tennis, and five minutes of exercises per eye using Guitar Hero. At the second session, subjects continued monocular exercises at higher difficulty levels.

During week two, bi-ocular training was introduced with anaglyphic red/green glasses and red/green filters over the television screen for Group 2. Group 1 wore the red/green glasses and used red and green pegs along with a red/green background on the rotator. The red buttons on the WSF also cancelled with the red/green glasses for Group 1. Participants maintained the same activities as in week one. Exercise difficulty was increased gradually at each session, in accordance with the subject's progress. Gross motor and cognitive distracters were added at the second session. Distracters included saying "hit" while hitting the ball for Wii Sports activities, reciting the alphabet from A to Z then Z to A, and counting out loud from one to 100 then 100 to one.

Binocular therapy activities were introduced in week three, with the difficulty levels increasing during week four. Additional distracters were added as needed, including muting the gaming system or WSF, stabilizing on a teeter board, or saying the color of key being played for Guitar Hero. In addition, speed and level difficulty were increased.

Therapy plans were adjusted on an individual basis during the study in accordance with subjects' levels. At the conclusion of the four weeks of vision therapy, each participant was reevaluated with DEM and Visagraph testing.

Results

Thirty-eight (16 males and 22 females) individuals ranging in age from 18 to 21 years (mean age of 18.74 ± 1.04 years) and meeting the requirements for normal ocular health and function participated. On the DEM, statistically significant improvements were noted for both groups' adjusted horizontal time results. Mean adjusted horizontal times for

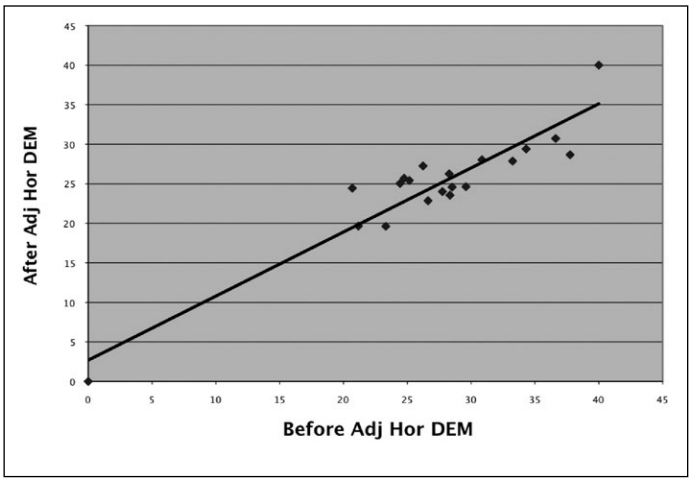

Figure 1: XY Plot (Control Group)

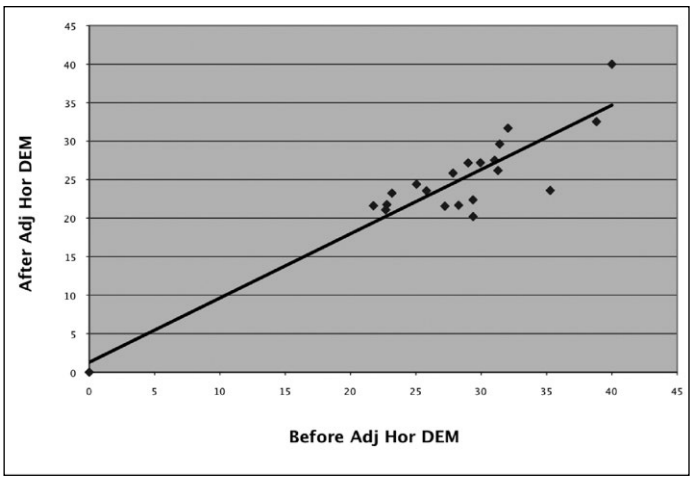

Figure 2: XY Plot (Wii Group)

Group 1 decreased from 28.20 to 25.43 seconds (p=0.002). Group 2 reduced the average adjusted horizontal time from 28.53 to 24.89 seconds (p<0.001).

The differences in calculated DEM ratios were compared. The ratio is calculated by dividing the adjusted horizontal time by the total vertical time. The mean DEM ratios before treatment were 1.06 ± 0.11 for Group 1 and 1.15 ± 0.14 for Group 2. After the four weeks of respective therapy programs, DEM ratios for both groups showed overall reductions; however, only the experimental group showed statistically significant improvement (1.05 ± 0.08 (p=0.663) for Group 1 and 1.05 ±0.10 (p=0.003) for Group 2). Although the data suggests improvement in saccadic skills for both groups, researchers have indicated that the DEM ratio may be a less reliable indicator of oculomotor dysfunction than the horizontal score, especially in higher grade levels.[10,14]

Reading rate and mean grade level efficiency were analyzed via the Visagraph before and after vision therapy. While change was noted, the final results did not reveal statistically significant findings for either average reading speed or grade level. Preliminary screening showed subjects in Group 1 held an average reading speed of 277.61 ± 124.01 words per minute (WPM) and grade level efficiency of 11.36 ± 3.41. Group 2 had an average reading speed of 284.95 ± 83.30 WPM and grade level efficiency of 11.83 ± 3.12. Following the vision therapy sessions, the reading speed of Group 1 decreased to 270.39 ± 663.14 WPM (p=0.683), but the reading level increased to 11.88 ± 2.39 (p=0.489). The reading speed of Group 2 increased to 304.11 ± 100.99 WPM (p=0.452) with an increased mean grade level of 12.10 ± 2.97 (p=0.772).

Bland-Altman analysis was further conducted to equivocate the effect of the treatment between the control and experimental groups.[15]

The XY plots of the before and after data for both the control (Figure 1) and experimental (Figure 2) groups had similar slopes to the trend line and showed comparable clustering of data points. However, the XY plots of the average and differences for the two groups showed slightly different results. The plot for Group 2 revealed a mean difference of 3.8 (Figure 3). Group 1 also showed an increased average difference in the adjusted horizontal DEM score at a measure of 2.4 (Figure 4).

Discussion

Results from the study indicate that using multisensory devices for vision therapy improves oculomotor skills, similar to or better than traditional procedures. Following either four weeks of Wii Sports and Guitar Hero or traditional therapy plans, noteworthy improvements in oculomotor skills were shown. DEM findings were significant. Independent t-test analysis indicated improvements in the adjusted horizontal time for both control and experimental groups. Additionally, the experimental group statistical improvement in DEM ratio scores, showing a potential improvement in reading performance. While Visagraph results were not found to be statistically significant, differences in means indicated minor improvements in reading level for both groups and in reading speed for Group 2. Results from the Visagraph may have been confounded by patient effort, repeatability of the test, or any slight variations in instructor directions. In addition, it should be noted that subjects were high-achieving honors students with no known visual problems, and results may differ with poorly achieving students or those struggling with visual problems that may affect reading. Orlansky et al.[16] cautioned against using the DEM alone for determining clinical therapy outcomes; however, the improvements found in this study still lend support to the use of electronic multisensory devices for vision therapy purposes. Analysis by the Bland-Altman method suggested that the Wii training may actually produce better results than traditional vision therapy practices. This provides further evidence that these types of devices can be incorporated into traditional oculomotor therapy programs to offer a variety of options for practitioners and patients.

While this study shows promise for incorporating new gaming systems into vision therapy procedures, it contains several limitations for which adjustments could be made in

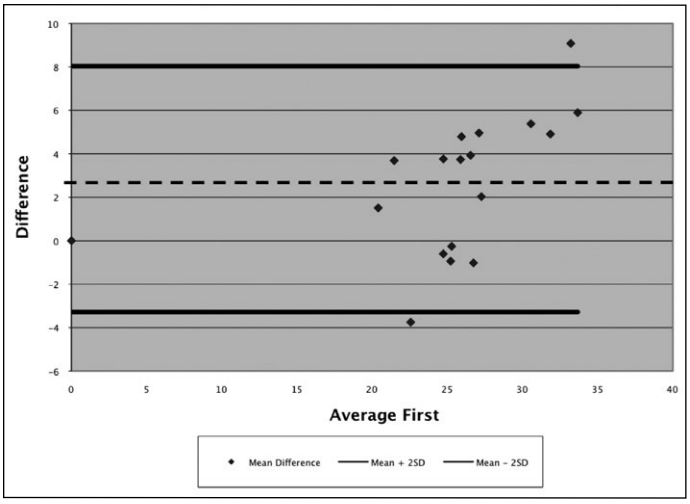

Figure 3: XY Plot of Average and Difference (Control Group)

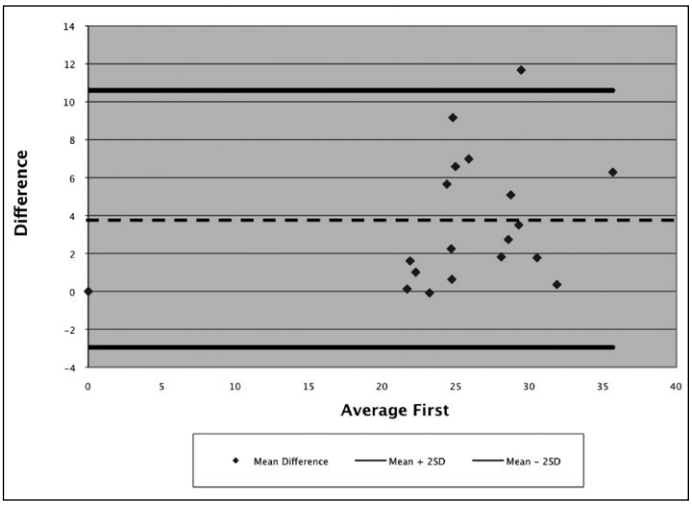

Figure 4: XY Plot of Average and Difference (Wii Group)

future research. The subject pool for this project consisted of healthy college students with normal binocular systems. Subjects with true oculomotor dysfunctions would better test the effectiveness of the Nintendo Wii system for vision therapy. While further research should be conducted to support the efficacy of using gaming devices, they appear to show a great potential for use within optometric vision therapy regimens.

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Correspondence regarding this article should be emailed to lyndsey.ferris@sheppard.af.mil or sent to Lyndsey M. Ferris, OD, 82 AMDS/SGPO, 149 Hart Street, Sheppard AFB, TX 76311. All statements are the authors' personal opinions and may not reflect the opinions of the the representative organizations, ACBO, COVD, or OEPF, Optometry & Visual Performance or any institution or organization with which the author may be affiliated.

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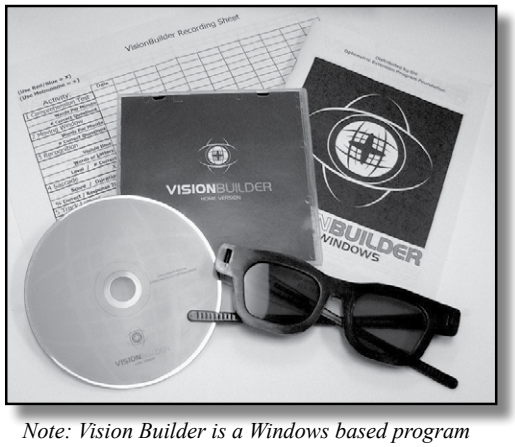

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