Virtual Reality Game-Based Automated Perimetry Performance in Healthy Children

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Introduction

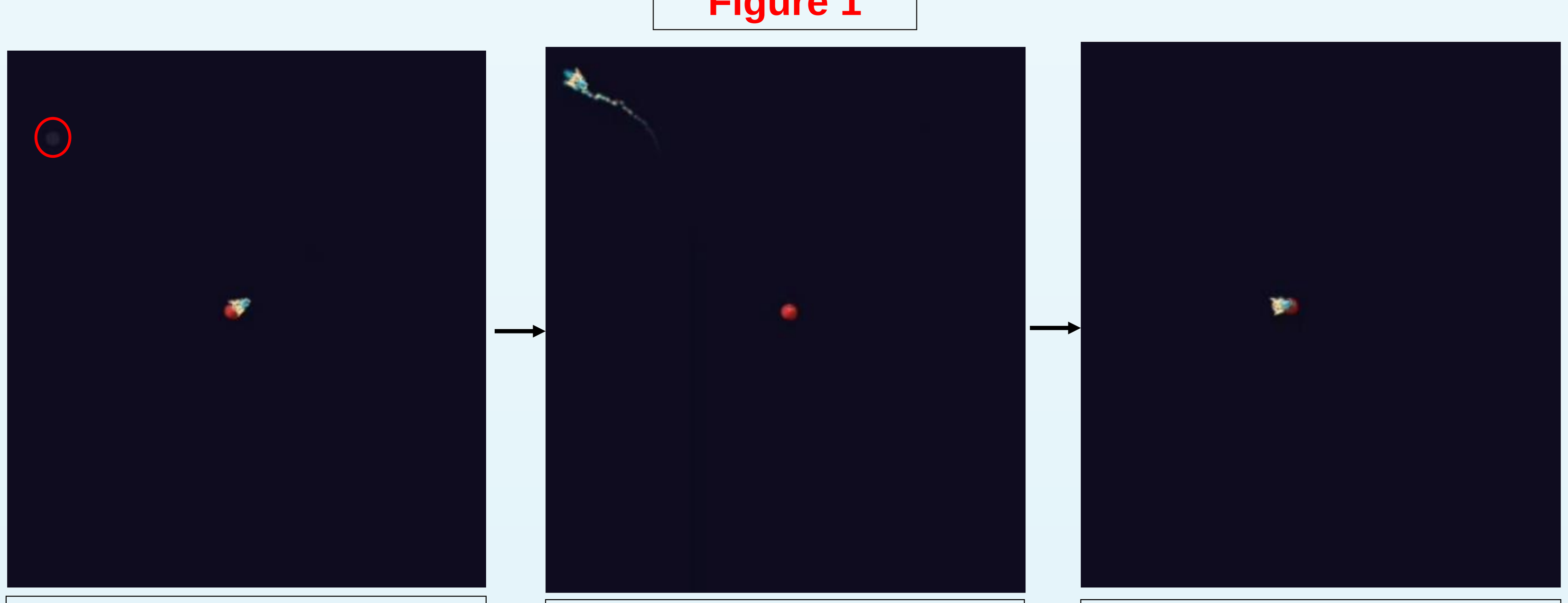
- Visual field testing is critical for evaluating patients in ophthalmology.
- Current standard of care for visual field testing is tabletop automated perimetry, such as in-office Humphrey Visual Field Test (HVF).
- HVF can be challenging for pediatric patients who often struggle with remaining focused and engaged, especially children younger than eight years.[1]
- Virtual reality (VR) technology has been explored as a potential tool in medical research, including within ophthalmology.
- VisuALL (Olleyes, Inc., Summit, NJ) is a portable VR-based field test previously described to be comparable to conventional HVF.[2,3,4] (Figure 1)
  - ✓ This VR system can perform a standard field test similar to HVF, but also allows a video game-like format for visual field assessment intended to appeal to children.
- **PURPOSE:** to characterize the performance of the VisuALL game-based field, termed Pediatric 24-2 AVA Standard visual field, in a healthy pediatric cohort.

Participants & Methods

- Children with healthy eyes presenting to Duke Eye Center for a visit with a pediatric optometrist or pediatric ophthalmologist were enrolled between January 2022 and December 2022.
- Inclusion criteria:
  - ✓ Visual acuity of 20/40 or better
  - ✓ No ocular diseases that interfere with visual field tests
  - ✓ No developmental delay
- The test settings and algorithm used was the VisuALL AVA standard strategy on a Pediatric 24-2 protocol with Goldmann size III, and foveal sensitivity measurement.
- Foveal sensitivity, individual sensitivities at all points, and global indices (mean deviation – MD and pattern standard deviation – PSD) were recorded.
- A short survey was completed at the end of the test to evaluate how the patient felt about the device.

Figure 1

A



The patient is asked to bring the rocket to the middle red dot. When in the middle, the stimuli flashes.

The patient is asked to move the rocket close to the white stimuli. When acquired, the devices dings.

After acquiring the stimuli, the patient returns the rocket to the middle red dot to continue testing.

B C

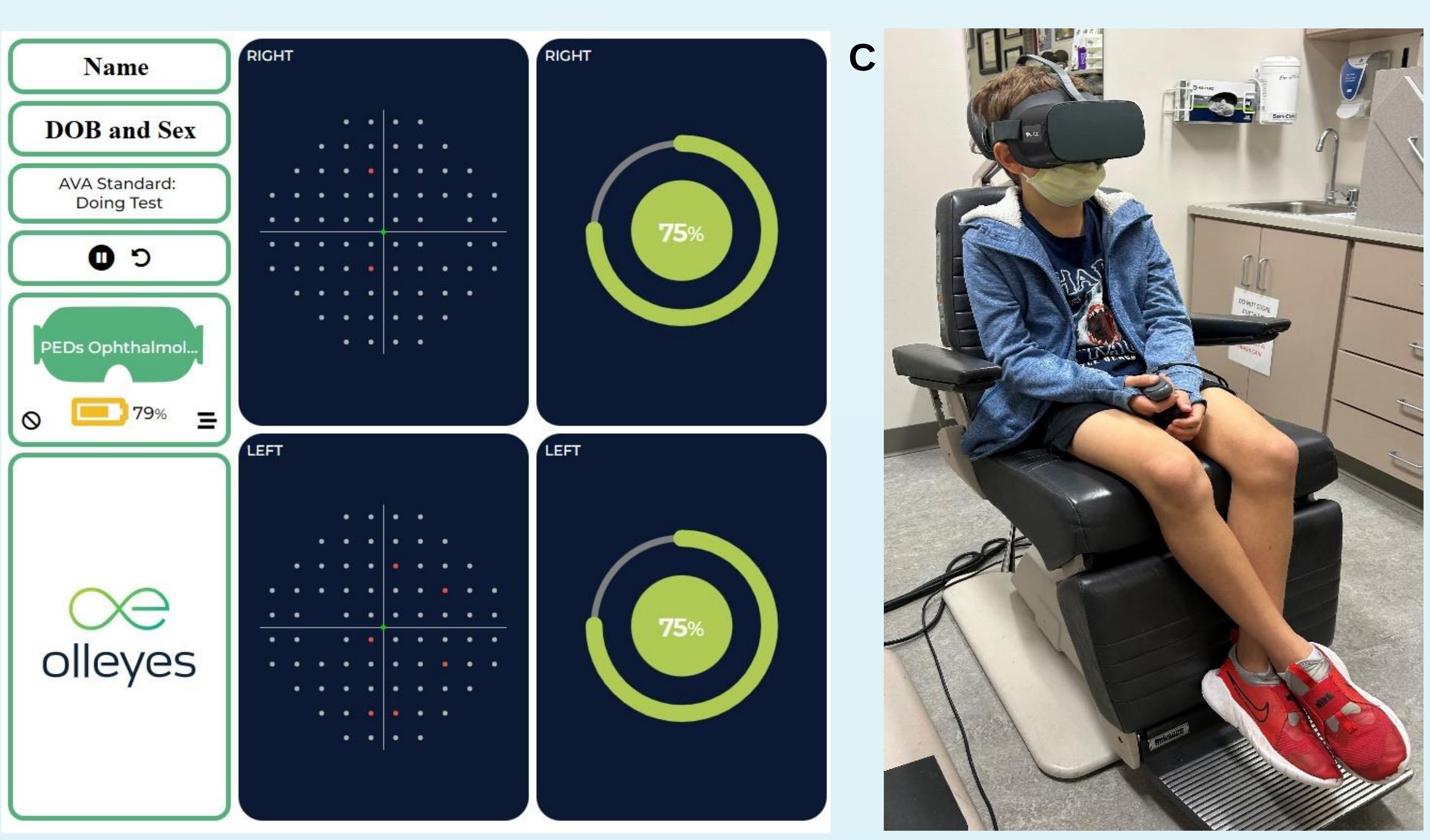


Figure 1: **A)** General testing paradigm for virtual reality visual field. The patient moves the rocket to "Mars" (red dot) and a white stimulus (red circle) is shown. After moving the rocket to the stimulus, the headset dings, patient is asked to bring the stimulus back to the central red dot to continue testing. **B)** Tester view at 75% completion,, showing the current field in the middle (white dots – captured stimulus, red dot – missed stimulus) and the percent of test completion to the right for each eye. **C)** Patient being fitted with the device before testing begins.

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Results

- Patient demographics (Table 1) and Heatmap VisuALL sensitivities (Figure 2).

Table 1. Patient demographics and characteristics

Characteristic	(n = 191 eyes of 97 patients)
Age at testing (years), mean ± SD	11.9 ± 3.1
Age breakdown:	
6-11, no. (%)	52 (54%)
12-14, no. (%)	25 (26%)
15-17, no. (%)	20 (21%)
Eye (right/left)	96/95
Visual Acuity (LogMAR), mean ± SD	0.06 ± 0.08
VisuALL	
Average sensitivity (dB), mean ± SD	29.2 ± 6.3
Mean deviation (dB), mean ± SD	-1.82 ± 3.5
Pattern standard deviation (dB), mean ± SD	3.48 ± 1.9
Foveal sensitivity (dB), mean ± SD	32.0 ± 4.7
Test duration (sec), mean ± SD	344 ± 98
Presenting Diagnosis	
Myopia or hyperopia, no. (%)	43 (44%)
Astigmatism, no. (%)	26 (27%)
Headaches or migraines, no. (%)	11 (11%)
Subjective visual disturbance, no. (%)	6 (6%)

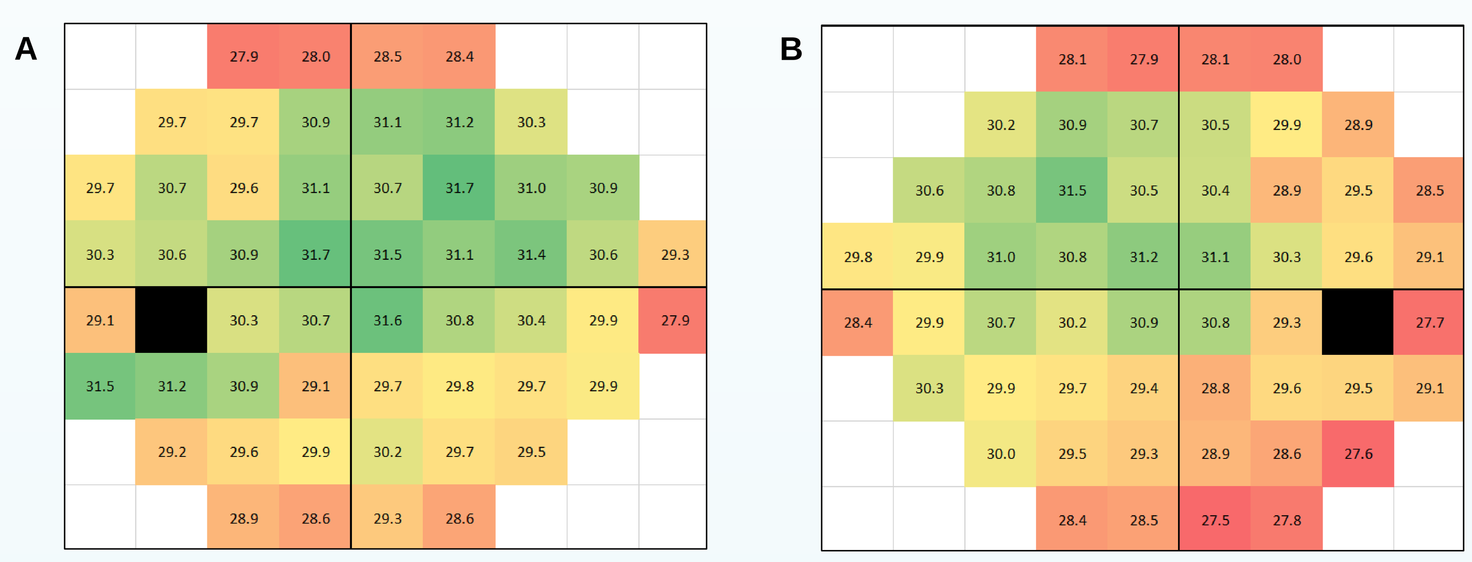

Figure 2. Heatmap distribution of point-by-point average analysis of the VisuALL visual field sensitivities plot for all patients in the **(A)** left eye and **(B)** right eye. Black – blind spot. In the heat map, red represents the lowest average, while dark green represents the highest average.

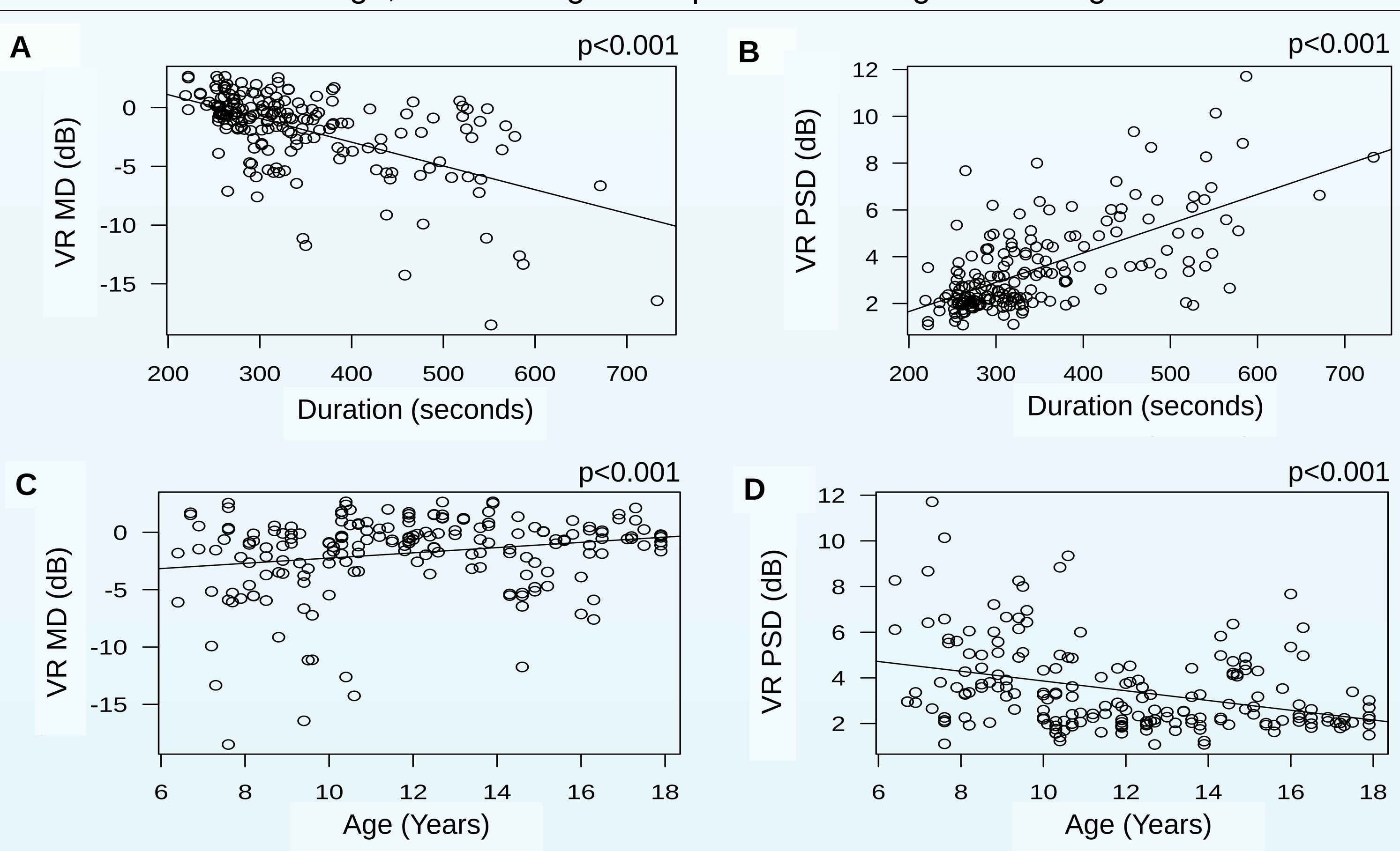

Figure 3. Scatter plot demonstrating the relationship of **(A)** mean deviation (MD) and **(B)** pattern standard deviation (PSD) to the duration of testing in seconds, and the relationship of **(C)** mean deviation (MD) and **(D)** pattern standard deviation (PSD) to the age of participants in years.

- Relationships between MD, PSD, test duration, and age are shown in Figure 3 above.
- False positives, wearing spectacles, Titmus stereoacuity, and refractive error were not associated with improved performance, once age was added as a covariate.
- 65 participants (67%) completed post-test questionnaire. 92% agree that they learned to use the device quickly and find the test to be friendly and simple.

Discussion / Limitations / Conclusion

- **Limitations**: limited number of patients, no comparison to HVF, and single-test data.
- Children with healthy eyes generally performed well using a game-based virtual reality visual field system.
- Younger age and longer test duration negatively influenced both the MD and PSD, consistent with previous literature.
- Our findings for mean overall sensitivity are similar to a previous study[2] with VisuALL using a different testing strategy, although our cohort was slightly younger (11.9 ± 3.1 vs. 13.0 ± 2.6 years, respectively).
- Virtual reality game-based perimetry is well tolerated and enjoyed in a healthy pediatric cohort and may prove valuable as an in-office and perhaps also home-based alternative to standard table-based testing.
- Future studies are necessary to evaluate the performance of VisuALL in children with various ocular pathologies, including home-based performance.

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