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Impact of Target Distance, Target Size, and Visual Acuity on the Video Head Impulse Test

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Abstract

The video head impulse test (vHIT) assesses the vestibuloocular reflex. Few have evaluated whether environmental factors or visual acuity influence the vHIT. The purpose of this study was to evaluate the influence of target distance, target size, and visual acuity on vHIT outcomes. Thirty-eight normal controls and 8 subjects with vestibular loss (VL) participated. vHIT was completed at 3 distances and with 3 target sizes. Normal controls were subdivided on the basis of visual acuity. Corrective saccade frequency, corrective saccade amplitude, and gain were tabulated. In the normal control group, there were no significant effects of target size or visual acuity for any vHIT outcome parameters; however, gain increased as target distance decreased. The VL group demonstrated higher corrective saccade frequency and amplitude and lower gain as compared with controls. In conclusion, decreasing target distance increases gain for normal controls but not subjects with VL. Preliminarily, visual acuity does not affect vHIT outcomes.

Keywords

vHIT; vision; distance; target size; vestibular

The video head impulse test (vHIT) is utilized in assessing patients with vestibular loss (VL) by measuring the vestibulo-ocular reflex (VOR).¹ vHIT is also used to differentiate peripheral from central lesions and to quantify the severity of VL.^{2–7} However, few have evaluated whether environmental factors or visual acuity influence vHIT.⁸

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Author Contributions

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During vHIT, individuals fixate on a visual target while small-amplitude, high-acceleration randomized head impulses are delivered.⁹ Individuals with VL are unable to maintain fixation on the target during head impulses toward the lesion side, leading to retinal slip, reduced gain, and repeatable corrective saccades (CSs).^{1,10,11}

Previous studies showed that decreasing target distance increases VOR gain, although this has not been demonstrated with vHIT.^{12–14} Additionally, no recommendations exist for target size or required visual acuity. The purpose of this study was to evaluate the influence of target distance, target size, and visual acuity on vHIT outcomes—specifically, CS frequency, CS amplitude, and gain.

Materials and Methods

This project was approved by the Boys Town National Research Hospital's Institutional Review Board. Subjects were recruited by direct solicitation or the Human Subjects Research Core at the hospital. Subjects aged 19 to 69 years were selected to mitigate age-related changes in vHIT.^{15–17}

Thirty-eight normal controls participated (mean age, 37.3 years; range, 22–63 years; 13 men). Visual acuity was determined with and without corrective lenses. Subjects with binocular vision >20/50 were classified as normal vision controls (NVCs; n = 24). Subjects with binocular vision ≤20/50 were classified as vision-impaired controls (VICs; n = 18). Four subjects wearing contact lenses were tested with and without corrected vision.

Eight subjects with VL participated (mean age, 45.9 years; range, 31–65 years; 5 men): 5 with unilateral VL and 3 with bilateral VL, for a total of 11 ears with VL.

Three target sizes were evaluated: small (0.18 cm), medium (0.71 cm), and large (5.1 cm), which corresponded to 20/20, 20/80, and 20/600 on the Snellen chart, respectively. Three target distances were evaluated: near (0.6 m), medium (1.2 m), and far (2.4 m). All subjects underwent vHIT at the medium distance first. Testing order was semi-randomized for target distance thereafter.

vHIT was administered with the ICS Impulse (Otometrics, Schaumburg, Illinois). Gain was calculated by the software by dividing eye velocity by head velocity via area under the curve with CS removed. Individual head impulses were analyzed in Matlab (version 2014a) where CS frequency and amplitude were determined within 500 milliseconds of head impulse initiation. CS ≤50° per second in amplitude was included. In the control group, right and left vHIT outcomes were averaged; in the VL group, only the affected side was analyzed. Analysis of variance and mixed-group factorial analysis of variance were completed. Post hoc testing was completed with Tukey's honestly significant difference.

Results

For normal controls, there was a significant effect of target distance on gain. Gain increased as distance decreased: far (0.94), medium (0.98), and near (1.04). There was no effect of

target distance on CS frequency or amplitude. There was also no effect of target size on CS frequency, CS amplitude, or gain (Table 1).

The normal control group was divided into 2 groups based on visual acuity (NVCs, $n = 24$; VICs, $n = 18$). The effect of visual acuity was evaluated with the medium target distance and the medium target size. There was no effect of visual acuity on CS frequency, CS amplitude, or gain (Table 2). As such, the normal control subjects remained combined ($n = 38$) for all remaining analyses.

For target distance, the VL group generated significantly higher CS frequency, higher CS amplitude, and lower gains as compared with normal controls (Figure 1, Table 1). Contrary to the normal controls, subjects with VL demonstrated significantly lower gain at the near (0.29) and medium (0.26) distances versus the far (.31) distance. For target size, the VL group generated significantly higher CS frequency, higher CS amplitude, and lower gain as compared with normal controls. Interestingly, post hoc analyses revealed that VL subjects generated higher gain to the large (0.30) versus small (0.27) and medium (0.26) targets.

Discussion

The effects of target distance, target size, and visual acuity on vHIT outcomes were evaluated. For normal controls, gain increased with decreased distance. This is attributed to vergence-mediated compensation for VOR gain at varying distances.^{18–20} However, subjects with VL demonstrated significantly lower gain at the near and medium distances versus the far distance, which may reflect the loss of vergence-mediated VOR changes.

There was no difference in CS frequency, CS amplitude, or gain between NVCs and VICs, preliminarily suggesting that visual acuity does not significantly influence vHIT outcomes. This finding is supported by Li et al, who similarly found no impact of visual acuity on gain in normal control subjects.²¹ Additionally, van Dooren et al found no difference in gain between subjects with and without corrective lenses or a relationship between gain and refractive error.⁸

Last, altering target size and distance did not affect differentiation between subjects with and without VL. Subjects with VL generated significantly higher CS frequencies, higher CS amplitudes, and lower gains as compared with normal control subjects for all conditions. While normal control subjects demonstrated nonpathologic CS, they could be discerned by amplitude and frequency when compared with subjects with VL.¹¹

The small sample size is a limitation as noted by small effect sizes (0.14–0.25), suggesting that large population studies are required to further identify the impact of visual acuity on vHIT and optimal testing conditions for identifying VL.

Disclosures

Competing interests: Amanda I. Rodriguez receives grant funding from the National Institutes of Health / National Institute on Deafness and Other Communication Disorders. Kamran Barin is a consultant to Interacoustics and Bertec Corp. He was also a consultant to Otometrics during the conception of this project. Kristen L. Janky does consulting regarding vestibular testing through Audiology Systems. She also receives grant funding from the National Institutes of Health / National Institute on Deafness and Other Communication Disorders.

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Figure 1.

Video head impulse test (vHIT) gain by (A) target distance and (B) target size by group: normal control (NC) and vestibular loss (VL). Mean gain between right and left ears is shown for NC, and affected ear gain is shown for subjects with VL. Values are presented as median (line), interquartile range (box), 95% CI (error bars), and outliers (circles). Circles and stars represent mild and extreme outliers, respectively.

Table 1.

Means (SD) and Statistical Outcomes for NC and VL Groups across All Conditions.

vHIT Outcome	Target Distance			Main Effects, <i>P</i> Value ^a		
	Near	Medium	Far	NC	Cond	NC vs VL
CS frequency						
VL	91.65 (16.79)	88.70 (13.92)	85.64 (19.39)			
NC	11.91 (17.22)	14.53 (19.68)	12.50 (19.79)	.337	<.001	.329
CS amplitude						
VL	-221.07 (68.18)	-209.83 (53.54)	-208.09 (56.44)			
NC	-46.63 (31.48)	-43.82 (30.31)	-36.34 (33.54)	.171	<.001	.096
vHIT gain						
VL	0.29 (0.22)	0.26 (0.21)	0.31 (0.23)			
NC	1.04 (0.08)	0.98 (0.07)	0.94 (0.09)	<.001	<.001	.002
Target Size						
	Small	Medium	Large			
CS frequency						
VL	76.04 (20.62)	88.70 (13.92)	83.01 (24.58)			
NC	14.02 (18.00)	14.53 (19.68)	14.14 (18.70)	.984	<.001	.130
CS amplitude						
VL	-210.51 (67.16)	-209.83 (53.54)	-212.42 (64.06)			
NC	-42.52 (30.93)	-43.82 (30.31)	-53.57 (31.55)	.172	<.001	.532
vHIT gain						
VL	0.27(0.21)	0.26 (0.21)	0.30 (0.23)			
NC	0.97 (0.08)	0.98 (0.07)	0.96 (0.07)	.152	<.001	.162

Abbreviations: cond, condition; CS, corrective saccade; NC, normal control; vHIT, video head impulse test; VL, vestibular loss.

^aEach effect represents a separate analysis of group, condition, and outcome. Significance set at *P*<.05.

Table 2.Mean (SD) and Statistical Outcomes for NVC and VIC Subjects.^a

vHIT Outcome	NVC (n = 24)	VIC (n = 18)	P Value
CS frequency	11.245 (12.45)	17.04 (25.32)	.335
CS amplitude	−37.94 (30.50)	−46.81 (30.98)	.359
vHIT gain	0.96 (0.05)	1.00 (0.10)	.165

Abbreviations: CS, corrective saccade; NVC, normal vision control; vHIT, video head impulse test; VIC, vision-impaired control.

^aSignificance set at $P < .05$.