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Effects of Device on Video Head Impulse Test (vHIT) Gain

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Kristen L. Janky*
Jessie N. Patterson†
Neil T. Shepard‡
Megan L. A. Thomas*
Julie A. Honaker†§

Abstract

Background: Numerous video head impulse test (vHIT) devices are available commercially; however, gain is not calculated uniformly. An evaluation of these devices/algorithms in healthy controls and patients with vestibular loss is necessary for comparing and synthesizing work that utilizes different devices and gain calculations.

Purpose: Using three commercially available vHIT devices/algorithms, the purpose of the present study was to compare: (1) horizontal canal vHIT gain among devices/algorithms in normal control subjects; (2) the effects of age on vHIT gain for each device/algorithm in normal control subjects; and (3) the clinical performance of horizontal canal vHIT gain between devices/algorithms for differentiating normal versus abnormal vestibular function.

Research Design: Prospective.

Study Sample: Sixty-one normal control adult subjects (range 20–78) and eleven adults with unilateral or bilateral vestibular loss (range 32–79).

Data Collection and Analysis: vHIT was administered using three different devices/algorithms, randomized in order, for each subject on the same day: (1) Impulse (Otometrics, Schaumberg, IL; monocular eye recording, right eye only; using area under the curve gain), (2) EyeSeeCam (Interacoustics, Denmark; monocular eye recording, left eye only; using instantaneous gain), and (3) VisualEyes (MicroMedical, Chatham, IL, binocular eye recording; using position gain).

Results: There was a significant mean difference in vHIT gain among devices/algorithms for both the normal control and vestibular loss groups. vHIT gain was significantly larger in the ipsilateral direction of the eye used to measure gain; however, in spite of the significant mean differences in vHIT gain among devices/algorithms and the significant directional bias, classification of “normal” versus “abnormal” gain is consistent across all compared devices/algorithms, with the exception of instantaneous gain at 40 msec. There was not an effect of age on vHIT gain up to 78 years regardless of the device/algorithm.

Conclusions: These findings support that vHIT gain is significantly different between devices/algorithms, suggesting that care should be taken when making direct comparisons of absolute gain values between devices/algorithms.

Key Words: aging, vestibular, video head impulse test

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*Boys Town National Research Hospital, Department of Audiology, Omaha, NE; †University of Nebraska-Lincoln, Department of Special Education and Communication Disorders, Lincoln, NE; ‡Mayo Clinic, Rochester, MN; §Cleveland Clinic, Cleveland, OH

Corresponding author: Kristen L. Janky, Boys Town National Research Hospital, Omaha, NE 68131; Email: kristen.janky@boystown.org

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K.L.J. provided consulting for Otometrics regarding the clinical use of vestibular evoked myogenic potential testing and video head impulse testing (vHIT) during this time frame. Boys Town Nation Research Hospital was a beta site for the Interacoustics EyeSeeCam. University of Nebraska Lincoln (JAH laboratory) was a beta site for MicroMedical vHIT system and Key opinion site with GN Otometrics.

Abbreviations: ANOVA = analysis of variance; AUC = area under the curve; ROC = receiver operating characteristic; SD = standard deviation; vHIT = video head impulse testing; VOR = vestibulo-ocular reflex

INTRODUCTION

The video head impulse test (vHIT) allows examiners to objectively assess the vestibulo-ocular reflex (VOR) during head impulses in the plane of each semicircular canal (horizontal, anterior, and posterior). The purpose of the VOR is to maintain steady vision during head movement by initiating a reflexive eye movement that is equal and opposite to that of head movement. During vHIT, a head-worn gyro-meter measures angular head velocity and an infrared camera measures angular eye velocity during each head impulse. In the event of abnormal VOR function, vHIT identifies both overt and covert corrective reset saccades (i.e., corrective reset saccades that occur after and during the head impulse, respectively), indicating abnormal VOR function and the inability to maintain steady vision during head movement (MacDougall et al, 2009). Advantages of vHIT over other clinical vestibular measures of canal function (e.g., calorics, rotary chair) are that it provides information regarding individual canal function, is quick to administer, and does not induce dizziness; however, its relationship to other tests of canal function suggests that vHIT is not a replacement to, but adjunctive to other tests of vestibular function (MacDougall et al, 2009; McCaslin et al, 2014; 2015; Bell et al, 2015; McGarvie et al, 2015a).

The most common outcome parameter reported with vHIT is VOR gain. VOR gain is calculated as the ratio of eye velocity to head velocity. Whereas numerous vHIT devices are available commercially, the gain is not calculated uniformly. To our knowledge, no study to date has compared the vHIT gain collected from different commercially available vHIT systems, which is necessary when comparing studies that have used different devices. Therefore, in the current study, three different vHIT devices were compared, with each calculating the vHIT gain using a different method: (a) instantaneous gain, (b) area-under-the-curve (AUC) gain, and (c) position gain. For instantaneous gain, the gain is calculated by dividing eye velocity by head velocity at a discrete point in time after the initiation of the head impulse (Figure 1A). For AUC gain, the gain is calculated by averaging instantaneous gain (eye velocity divided by head velocity at every point; cumulative gain) across the duration of the head impulse (zero crossing point; Figure 1B, shown by dotted lines). Reset saccades interfere with gain calculations using AUC by artificially inflating the gain; therefore, the gain is calculated on desaccaded waveforms (reset saccade removed; Figure 1B, removal of the reset saccade shown by black shading). For position gain, the gain is calculated by dividing the total eye rotation (in degrees) by total head rotation (in degrees) from the time the head impulse is initiated

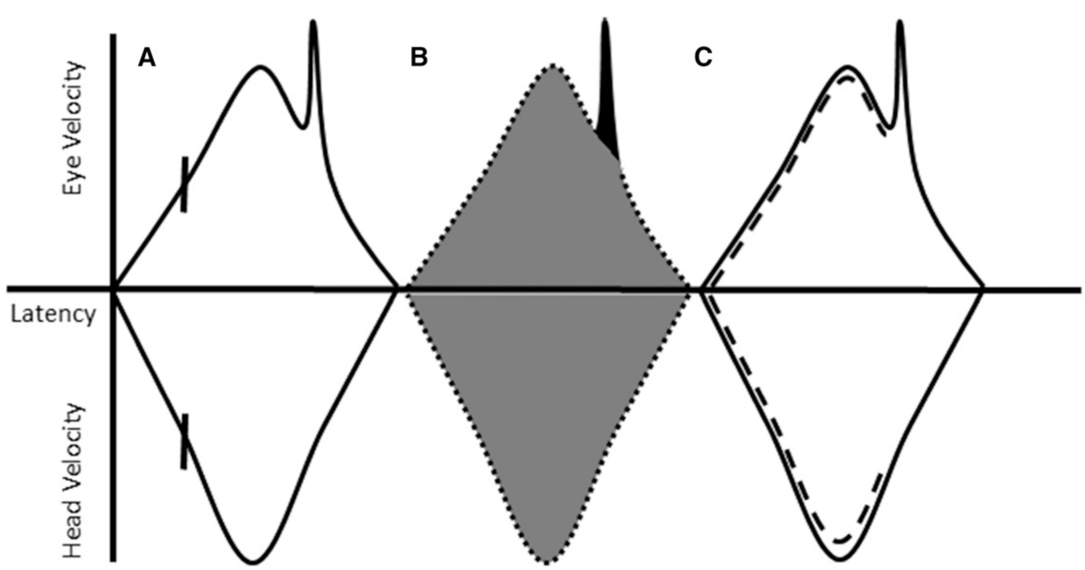

Figure 1. Reduced eye velocity, which would produce reduced gain, with a covert reset saccade is depicted in the top panel with corresponding head velocity shown in the bottom panel during a head impulse for three types of gain algorithms: (A) Instantaneous gain (Interacoustics EyeSeeCam), calculated by dividing eye velocity by head velocity at a discrete point in time; (B) AUC gain (Otometrics, Impulse), calculated by averaging instantaneous gain across the entire duration of the head impulse, not including any covert saccade (dotted line); and (C) position gain (Micromedical VisualEyes), calculated by dividing the total eye rotation (in degrees) by total head rotation (in degrees) from the time the head impulse is initiated to the start of a corrective reset saccade (hashed line).

to the zero crossing, when normal, or to the start of a corrective reset saccade, when abnormal (Figure 1C, shown by dashed lines). This is effectively the same as measuring AUC, but with a different stopping point. It is unknown if these different devices, using different methods of gain calculation, yield similar gain values for individuals with normal and abnormal vestibular function.

Whereas other tests of vestibular function have demonstrated vulnerability to aging, minimal effect of age has been documented with respect to vHIT gain (Davalos-Bichara and Agrawal, 2014; Matiño-Soler et al, 2015; McGarvie et al, 2015b; Mossman et al, 2015). Age has been shown to have little effect on vHIT gain until the eighth or ninth decade of life (Davalos-Bichara and Agrawal, 2014; Matiño-Soler et al, 2015; McGarvie et al, 2015b; Mossman et al, 2015), but this work has not been replicated and evaluated with all devices. Therefore, a second aim of the current study was to evaluate the effect of age on vHIT gain for each vHIT device and gain algorithm.

We hypothesize no significant differences in lateral canal angular gain values among three commercial vHIT devices, each using a different VOR gain algorithm; however, subtle differences may occur, which could affect the clinical performance or the comparison of data obtained with different devices. Therefore, using three commercially available vHIT devices, the purpose of the present study was threefold, to compare (a) horizontal canal vHIT gain among devices in normal control participants; (b) the effects of age on vHIT gain for each device in normal control participants; and (c) the clinical performance of horizontal canal vHIT gain among devices for differentiating normal versus abnormal vestibular function.

MATERIALS AND METHODS

Study Population

Control Sample

Sixty-one normal control adult participants (mean age = 49, range = 20–78, 25 males, 10 participants per decade) participated in the study. By case history, all control participants denied significant hearing loss or history of dizziness, imbalance, or other neurologic complaints.

Patient Sample

Eleven adults with unilateral or bilateral vestibular loss (mean age = 52.3, range = 32–79, 2 males) also participated. Unilateral vestibular loss was diagnosed by caloric weakness (>30%). Bilateral vestibular loss was diagnosed by reduced sinusoidal harmonic acceleration rotary chair gains across the frequency spectrum up to 0.32 Hz. Of the 11 adults with vestibular loss, three had bilateral loss (six ears affected) and eight had unilateral loss (four left and four right ears affected, mean caloric weakness = 70%, range = 43–91) for a total of 14 ears affected with vestibular loss.

Informed consent was obtained from all participants for testing approved by the Institutional Review Boards at Boys Town National Research Hospital and the University of Nebraska-Lincoln.

vHIT

The vHIT was administered using three different devices/algorithms, randomized in order for each participant on the same day: (a) Impulse (Otometrics, Schaumberg, IL; monocular eye recording, right eye only, using AUC gain; software version: 1.2), (b) EyeSeeCam (Interacoustics, Denmark; monocular eye recording, left eye only, using instantaneous gain; software version: 1.1.1), and (c) VisualEyes (Micromedical, Chatham, IL; binocular eye recording, using position gain; software version: 8.11A). All head impulses were completed by three examiners (K.L.J., J.A.H., and J.P.). For any given participant, the same examiner completed the vHIT for each device. Each device was calibrated according to manufacture recommendations. For each vHIT, the participants were seated 1 m from a visual target mounted at eye level on the wall. The examiner stood behind the participant, placed hands on the participant's chin, and delivered randomized (timing and direction) head impulses (100–250°/sec peak head velocity) in the plane of the horizontal semicircular canal. Each manufacturer used different criteria for the number of impulses required. Interacoustics EyeSeeCam had no criteria, so testing was stopped when approximately 20 head impulses were acquired for each side, Otometrics Impulse required 20 acceptable head impulses for each side, and Micromedical VisualEyes required 10 acceptable head impulses for each side. The outcome parameter was gain, which was calculated differently for each device: (a) Instantaneous gain (Figure 1A; Interacoustics, EyeSeeCam); (b) AUC (Figure 1B; Otometrics, Impulse); and (c) Position gain (Figure 1C; Micromedical, VisualEyes). Of note, vHIT gains using the position gain were automatically rounded by the software.

Statistical Analyses

Either a paired samples *t*-test or a within-groups analysis of variance (ANOVA) was completed to evaluate the effects of impulse side (rightward versus leftward) on vHIT gain for each device/algorithm. Correlations were calculated to investigate the relationship between vHIT gain and age. A within-groups

ANOVA was completed to evaluate mean differences in vHIT gains between the three devices/algorithms. All post hoc analyses used Tukey's procedure. To determine clinical accuracy of the different devices/algorithms for detecting vestibular loss (control versus patient sample with significant caloric weakness), Receiver operating characteristic (ROC) curves and AUC were calculated, where an area of 1 represents a perfect separation of controls from patients and an area of 0.5 represents a test with poor diagnostic accuracy.

RESULTS

The effects of vHIT device/algorithm and age on the horizontal canal vHIT gain in normal control participants

- Instantaneous gain: For instantaneous gain (measured using the left eye, Interacoustics EyeSeeCam), the gain was calculated for rightward and leftward head impulses as the median value at three latencies: 40, 60, and 80 msec after the initiation of the head impulse, shown in Table 1. A within-groups ANOVA was completed with impulse side (rightward versus leftward) and latency (40, 60, and 80 msec) as the within-subjects factors. There was a main effect of impulse side ($F_{[1,\ 60]} = 19.34$, $p < 0.001$), with significantly higher mean gain for leftward (0.99) compared with rightward (0.94) head impulses. When interpreting the simple effects, as shown by an asterisk (*) in Table 1, the mean gain was significantly higher in the eye ipsilateral to the direction of head impulse for 40 and 60 msec. There was also a main effect of latency ($F_{[2,\ 120]} = 22.86$, $p < 0.001$), with the gain significantly increasing as the latency increased from 40 msec (0.91) to 60 msec (0.97) and to 80 msec (1.01). There was a significant interaction between impulse side and latency ($F_{[2,\ 120]} = 3.442$, $p = 0.04$), with differences in gains being more pronounced between the latencies for rightward compared with leftward head impulses. Age was weakly correlated with the mean vHIT gain at 40 msec ($r = 0.27$, $p = 0.037$), but not correlated at 60 ($r = 0.18$, $p = 0.16$) or 80 msec ($r = 0.14$, $p = 0.3$).
- AUC gain: For AUC gain (measured using the right eye, Otometrics Impulse), the gain for rightward and leftward head impulses are shown in Table 1. Data from one participant were dropped as gains were greater than three standard deviations (SDs) from the mean (1.39 and 1.2 for right and left vHIT, respectively), suggesting a possible calibration error (Mantokoudis et al, 2015). A paired samples *t*-test was completed comparing rightward and leftward head impulses. Significantly higher mean gain was noted for rightward (0.99) versus leftward (0.92) head impulses ($t = 8.19$, $p < 0.001$), as denoted by an asterisk in Table 1. There was no significant correlation between age and mean vHIT gain ($r = -0.17$, $p = 0.19$).
- Position gain: For position gain (using both eyes simultaneously, Micromedical VisualEyes), gains for rightward and leftward head impulses are shown in Table 1. A within-groups ANOVA was completed with impulse side and eye (right versus left) as the within-subjects factors. For ten participants, data were only available for either the right or left eye; therefore, these data were not included in the repeated measures analysis. There was no main effect of impulse side ($F_{[1,\ 51]} = 1.24$, $p = 0.27$) or eye ($F_{[1,\ 51]} = 0.01$, $p = 0.92$); however, there was a significant interaction between impulse side and eye ($F_{[1,\ 51]} = 52.63$, $p < 0.001$). When interpreting the simple effects, as shown by an asterisk (*) in Table 1, the mean gain was significantly higher in the eye ipsilateral to the direction of head impulse. Age was not significantly correlated with vHIT gain for eye (right: $r = 0.09$, $p = 0.49$; left: $r = 0.09$, $p = 0.49$).

There was no relationship between vHIT gain and age in the normal control participants for any of the three devices/algorithms, with the exception of instantaneous gain at 40 msec. However, vHIT gain was significantly larger in the ipsilateral direction of the eye used to measure gain. Because vHIT was measured with different eyes for different devices, gains in response to rightward and leftward head impulses were averaged for each device to eliminate this directional bias; the normal control

Table 1. Mean vHIT Gain Values

	AUC	Instantaneous Gain			Position Gain	
Mean vHIT Gain	Right Eye	Left Eye 40 msec	Left Eye 60 msec	Left Eye 80 msec	Right Eye	Left Eye
Normal control rightward	0.99* [0.09]	0.89 [0.18]	0.94 [0.14]	1.0 [0.11]	1.08* [0.13]	1.01 [0.14]
Normal control leftward	0.92 [0.07]	0.94* [0.18]	1.0* [0.1]	1.01 [0.09]	1.02 [0.13]	1.09* [0.14]
Normal control average	0.95 [0.09]	0.91 [0.18]	0.97 [0.13]	1.01 [0.10]	1.05 [0.12]	1.04 [0.13]
Vestibular affected ear	0.32 [0.1]	0.31 [0.18]	0.25 [0.14]	0.32 [0.18]	0.49 [0.13]	0.46 [0.13]

Notes: Mean [SD] vHIT gain values for rightward, leftward, and overall (right and left combined) head impulses using AUC gain, instantaneous gain, and position gain.

*Denotes significantly higher gain value compared with contralateral impulse.

average values are shown in the third row of Table 1. When comparing vHIT gains across devices/algorithms, gain values with the least variability (i.e., smallest SD) were used. Therefore, a within-groups ANOVA using the mean [SD] gain for AUC (0.95 [0.09]), mean gain at 80 msec for instantaneous gain (1.01 [0.1]), and mean gain for the right eye for position gain (1.05 [0.12]) was calculated to evaluate for differences between devices/algorithms. There was a significant main effect for device/algorithm ($F_{[2,\ 110]} = 20.25$, $p < 0.001$); post hoc analysis revealed that AUC gain was significantly lower than instantaneous gain at 80 msec ($p < 0.001$) and position gain ($p < 0.001$), and that instantaneous gain at 80 msec was significantly lower than position gain ($p = 0.02$), Figure 2 and Table 1.

The Effect of vHIT Device/Algorithm for Differentiating Normal versus Abnormal Vestibular Function

Abnormal vHIT gain was defined as being lower than two SDs from the normal control average (Table 1). Example vHIT waveforms of a participant with left vestibular loss are shown in Figure 3 for each device/algorithm. The vHIT gain from the normal control group and the gain from the "affected" ear of the vestibular group were plotted in Figure 4; as shown, of the 14 ears affected with vestibular loss, ears were classified similarly on all devices/algorithms as having normal vHIT gain versus abnormal vHIT gain, with the exception of instantaneous gain at 40 msec, where one participant with abnormal gain for all other devices/algorithms demonstrated overlap with the normal control group. It should be noted that data from 3/14 ears for instantaneous gain were lost because of software failure; therefore, data from 11/14 ears are reported for instantaneous gain. These results suggest that in spite of the statistically significant mean differences in vHIT gains between devices/algorithms and the significant directional bias (significantly larger vHIT gain in the ipsilateral direction of the eye used to measure gain), classification of "normal" versus "abnormal" gain is consistent across devices/algorithms with the exception of instantaneous gain at 40 msec.

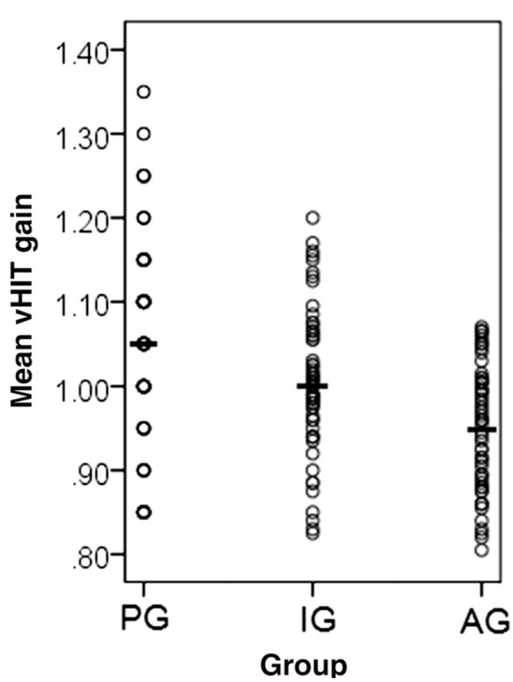

Figure 2. Mean (rightward and leftward impulses) vHIT gain in the normal control participants for each algorithm: PG = position gain; IG = instantaneous gain; and AG = AUC gain. Mean vHIT gain shown by horizontal bar.

A within-groups ANOVA was calculated to evaluate differences in mean gains between devices/algorithms in the ears with abnormal vHIT gain: mean [SD] gain for AUC (0.32 [0.1]), mean gain at 80 msec for instantaneous gain (0.32 [0.18]), and mean gain for the right eye for position gain (0.49 [0.13]). There was a significant main effect for device/algorithm ($F_{[2,\ 16]} = 4.39$, $p = 0.03$); post hoc analysis revealed that position gain was significantly larger than both AUC and instantaneous gain at 80 msec. There was no significant difference between AUC and instantaneous gain at 80 msec, Table 1.

ROC curves and AUC were calculated between the vestibular (abnormal caloric weakness) and normal control groups for each of the devices/algorithms, Table 2. Whereas these AUC values suggest good agreement among devices/algorithms, the data also highlight a discrepancy between caloric and vHIT results, given the AUC values <1.0.

DISCUSSION

A variety of vHIT devices are available commercially; however, gain is not calculated uniformly among devices. Thus, the purpose of this study was to examine vHIT gain across a wide age range and investigate the clinical performance of three different vHIT devices, each using a different VOR gain algorithm, for identifying peripheral vestibular system dysfunction.

Regardless of device/algorithm, there were no significant relationships between vHIT gain and age in the normal control participants <78 yr of age. This finding is consistent with others. Age-related decrements in vHIT VOR gain have been noted in normal control populations in the eighth or ninth decade of life (Davalos-Bichara and Agrawal, 2014; Matiño-Soler et al, 2015; McGarvie et al, 2015b; Mossman et al, 2015); however, we did not perform vHIT on participants >78 yr of age. The lack of age-related changes on VOR gain is in contrast to the anatomic and physiologic data that show the onset of age effects before the sixth and seventh

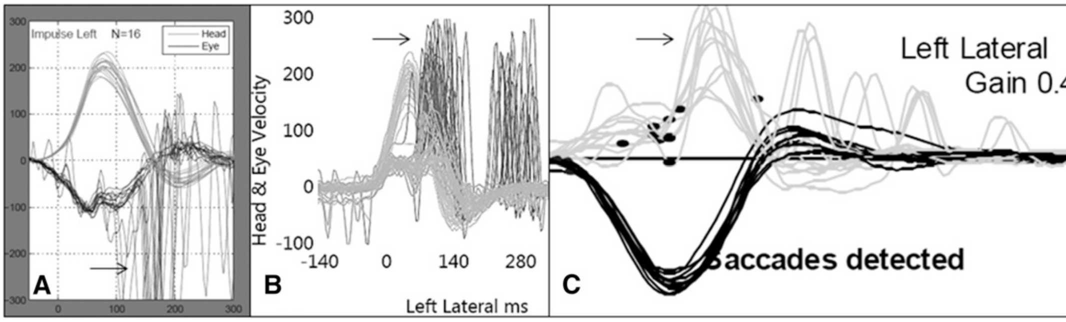

Figure 3. Example vHIT waveforms in one participant with left vestibular loss for each device/algorithm: (A) Instantaneous gain (gain = 0.54), (B) AUC gain (gain = 0.45), and (C) position gain (gain = 0.4). For each segment, time is along the *x*-axis, and eye and head velocity are along the *y*-axis. Arrows notate corrective reset saccades.

decades via histological studies documenting physiological reductions in receptor function (Rosenhall, 1973; Engström et al, 1974) and the vulnerability of other tests of vestibular function to age (Janky and Shepard, 2009; Agrawal et al, 2012; Taylor et al, 2012). However, McGarvie et al (2015b) suggest that the cerebellum is instrumental in VOR repair and could be responsible for overcoming the effects of age in vHIT.

vHIT gains were significantly larger in the ipsilateral direction of the eye used to measure gain. Whereas some investigators report symmetrical mean gain between right and left sides in normal control populations (Weber et al, 2008a), a similar directional bias has been reported (Weber et al, 2008b; Matiño-Soler et al, 2015; McGarvie et al, 2015b; Yip et al, 2016). The difference in VOR gains between right and leftward impulses has been attributed to the "demand" placed on each eye during head rotation; for instance, when gain is measured over the right eye, rightward head rotations result in larger right eye versus left eye rotations to maintain steady gaze (i.e., larger demand) and vice versa for leftward rotations (McGarvie et al, 2015b). This directional bias has also been attributed to differences in the neural pathway between the ipsilateral and contralateral rectus muscles (Weber et al, 2008b). Results of the current study are consistent with these suggestions, and this pattern of findings remained consistent regardless of the eye used to measure the vHIT gain. In spite of this directional bias, there were no differences in the ROC AUC values between devices/algorithms for identifying individuals with vHIT gain abnormalities. These findings suggest that each device/algorithm performs equally well at discriminating between normal versus abnormal vHIT gain and that the interocular difference

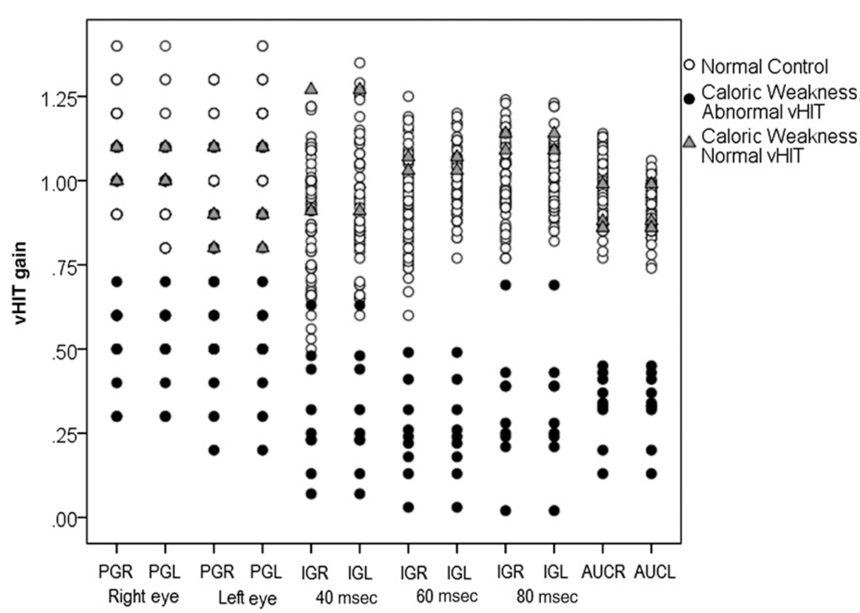

Figure 4. vHIT gain in the normal control and vestibular loss groups across devices. Of note, vHIT gains using position gain are automatically rounded by the software. PG = position gain; IG = instantaneous gain; AUC = area under the curve gain; R = right; and L = left; 40, 60, and 80 correspond to the msec at which the instantaneous gain was measured.

Table 2. ROC AUC Values

		Position Gain		Instantaneous Gain			AUC
		Right Eye	Left Eye	Left Eye 40 msec	Left Eye 60 msec	Left Eye 80 msec	
ROC AUC values	Rightward	0.899	0.870	0.860	0.862	0.849	0.945
	Leftward	0.857	0.920	0.865	0.876	0.841	0.885

Note: ROC AUC values close to 1.0 = diagnostic accuracy in identifying peripheral vestibular loss; ROC AUC values close to 0.5 = poor diagnostic accuracy.

due to camera placement does not affect clinical performance, with the exception of instantaneous gain at 40 msec.

In the current study, instantaneous gain was calculated at 40, 60, and 80 msec after the initiation of the head impulse, according to manufacturer specification. Findings suggest that there is an effect of latency on the clinical accuracy of vHIT gain and that 60 and 80 msec are the preferred latencies for the detection of abnormal vHIT gain.

Mean vHIT gains were also significantly different among devices/algorithms. In normal control participants, the AUC gain was significantly lower than the instantaneous gain and position gain, and the instantaneous gain was significantly lower than the position gain. In participants with vestibular loss, position gain was significantly higher than both instantaneous gain and AUC gain. These findings suggest that whereas each device/algorithm performs equally well at discriminating normal versus abnormal VOR function, care should be taken when making direct comparisons of gain obtained using different devices.

Lastly, we examined the clinical performance of vHIT for identifying peripheral vestibular system dysfunction. All devices/algorithms performed equally well at identifying participants with a significant caloric weakness; however, there was a disassociation between the caloric test and vHIT given the AUC values <1.0. Several theories have been posed for the disassociation between the vHIT gain and caloric asymmetry. One factor is the difference in stimulus frequency of the vHIT and caloric test. The caloric stimulus is a low-frequency assessment of vestibular function, whereas the vHIT is a high-frequency assessment (McCaslin et al, 2014; Blödow et al, 2015). A second factor is the extent of physiologic involvement in specific patient populations. Several theories have been postulated with respect to Ménière's disease. One theory is that the membraneous labyrinth becomes distended throughout the course of Ménière's disease, increasing volume of the labyrinth (McGarvie et al, 2015a). This disrupts the convective flow of endolymph during caloric stimulation, thus resulting in a caloric weakness yet normal vHIT (McGarvie et al, 2015a). A second theory is that Ménière's disease may selectively impair type I versus type II hair cells (Tsuji et al, 2000). Further understanding of this discrepancy is beyond the scope of this manuscript; however, our findings suggest that this discrepancy is tied to physiologic factors and not related to device/algorithm. Interestingly, in our 11 vestibular patients, four demonstrated normal vHIT gain; of those, two were diagnosed with definite Ménière's disease, one with probable Ménière's disease, and one with unspecified vestibular dysfunction (Lopez-Escamez et al, 2016).

Examiner-related factors could also account for this disassociation. vHIT gain reductions are more likely to occur as head acceleration increases (Weber et al, 2008a). Therefore, head velocities that exceed 150°/sec are recommended (McGarvie et al, 2015b). One limitation of the current study is that two of the three vHIT devices did not provide mean head velocity as an outcome parameter; these data were only available on data export. The Impulse (Otometrics) device provides mean head velocity data, which were 158°/sec for rightward head impulses and 166°/sec for leftward impulses. Data were exported from the EyeSeeCam (Interacoustics) and noted to be 177°/sec overall. Whereas mean head velocity data were unavailable for export from the Visual Eyes (MicroMedical) device, their algorithm does not accept head impulses less than 150°/sec suggesting velocities to be within a similar range. For the Interacoustics EyeSeeCam and Otometrics Impulse, head velocities that fell below 150°/sec were included in the final mean gain calculation; however, specific cut-off values can now be set in all of the devices because of the updated software versions not available at the time of data collection. It is unknown if the inclusion of head velocities less than 150°/sec affects test interpretation.

Some additional limitations of the current study are that our normal control population did not extend >80 yr, which has been documented as a critical age where vHIT abnormalities related to age begin to surface (Davalos-Bichara and Agrawal, 2014; Matiño-Soler et al, 2015; McGarvie et al, 2015b). We also had a small number of individuals with vestibular loss who completed the vHIT on all three devices. Additionally, differences between the three commercial vHIT devices extend beyond their gain algorithms. Each vHIT device differs in their resolution, sampling rate, filtering, and calibration, among other factors; therefore, differences between the devices cannot be attributed solely to differences in gain algorithms. One noteworthy difference is the calculation of position gain where vHIT gains were automatically rounded by the software. This difference is evident when analyzing the raw data in Figures 2 and 4, which demonstrate gain values in factors of 0.05. Comparison of these three commercial devices was also not compared against the gold standard coil system. Previous findings suggest good agreement between vHIT and coils, although this has not been replicated with various devices/algorithms (MacDougall et al, 2009).

CONCLUSIONS

Our data support that there is not an effect of age on the vHIT gain ≤78 yr, regardless of the device/algorithm used to calculate the gain. There was a consistent directional bias, with the vHIT gain being significantly larger in the ipsilateral direction of the eye used to measure the gain; however, clinical performance for identifying vestibular involvement was not significantly affected. The vHIT gain is significantly different between devices, suggesting that care should be taken when making direct comparisons of absolute gain values from these devices/algorithms.

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