# Binocular Video Head Impulse Test in Health and Disease

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## Background

The video head impulse test (vHIT) evaluates the vestibulo-ocular reflex (VOR). It's usually recorded from only one eye. Newer vHIT devices allow a binocular quantification of the VOR.

Aim: To investigate the advantages of simultaneously recorded binocular vHIT (bvHIT) to detect the differences between the VOR gains of the ADducting and the ABducting eye, to define the most precise VOR measure, and to assess gaze dysconjugacy. We aimed to establish normative values for bvHIT ADducting/ABducting eye VOR gains and to introduce the VOR dysconjugacy ratio (vorDR) between ADducting and ABducting eyes for bvHIT. In addition, we present first results in patients with a unilateral vestibular deficit (UVD).

## Methods

We enrolled 44 healthy adult participants and 44 UVD patients in a cross-sectional, prospective study using a repeated-measures design to assess test-retest reliability. An EyeSeeCam Sci 2 device was used to record bvHIT from both eyes simultaneously during impulsive head stimulation in the horizontal plane.

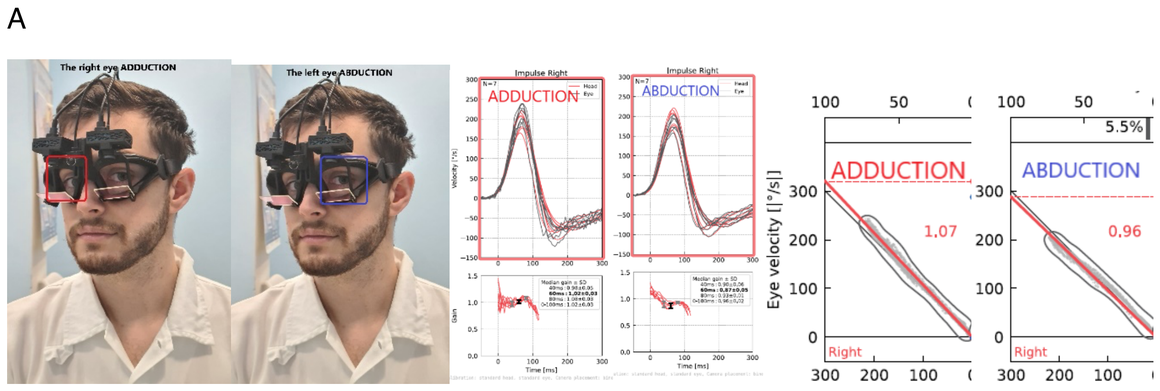


**Fig. 1:** Comparison of the conjugacy of leftward gaze during rightward vHIT (A) and rightward gaze during leftward vHIT (B): In this exemplary case, the ADduction/ABduction dysconjugacy ratios (vorDR) are 1.07/0.96=1.11 for both leftward and rightward vHIT.

## Results

Pooled bvHIT retest gains of the adducting eye significantly exceeded those of the abducting eye (mean (SD): 1.08 (0.06), 0.95 (0.06), respectively). Both adduction and abduction gains showed similar variability, suggesting comparable precision and therefore equal suitability for VOR asymmetry assessment. The pooled vorDR here introduced to bvHIT was 1.13 (SD = 0.05). The test-retest repeatability coefficient was 0.06.

In UVD patients, the AD and AB gains of the ipsi- and contralateral sides were, respectively: 0.57 (0.20), 0.97 (0.14), 0.48 (0.18), 0.85 (0.11)

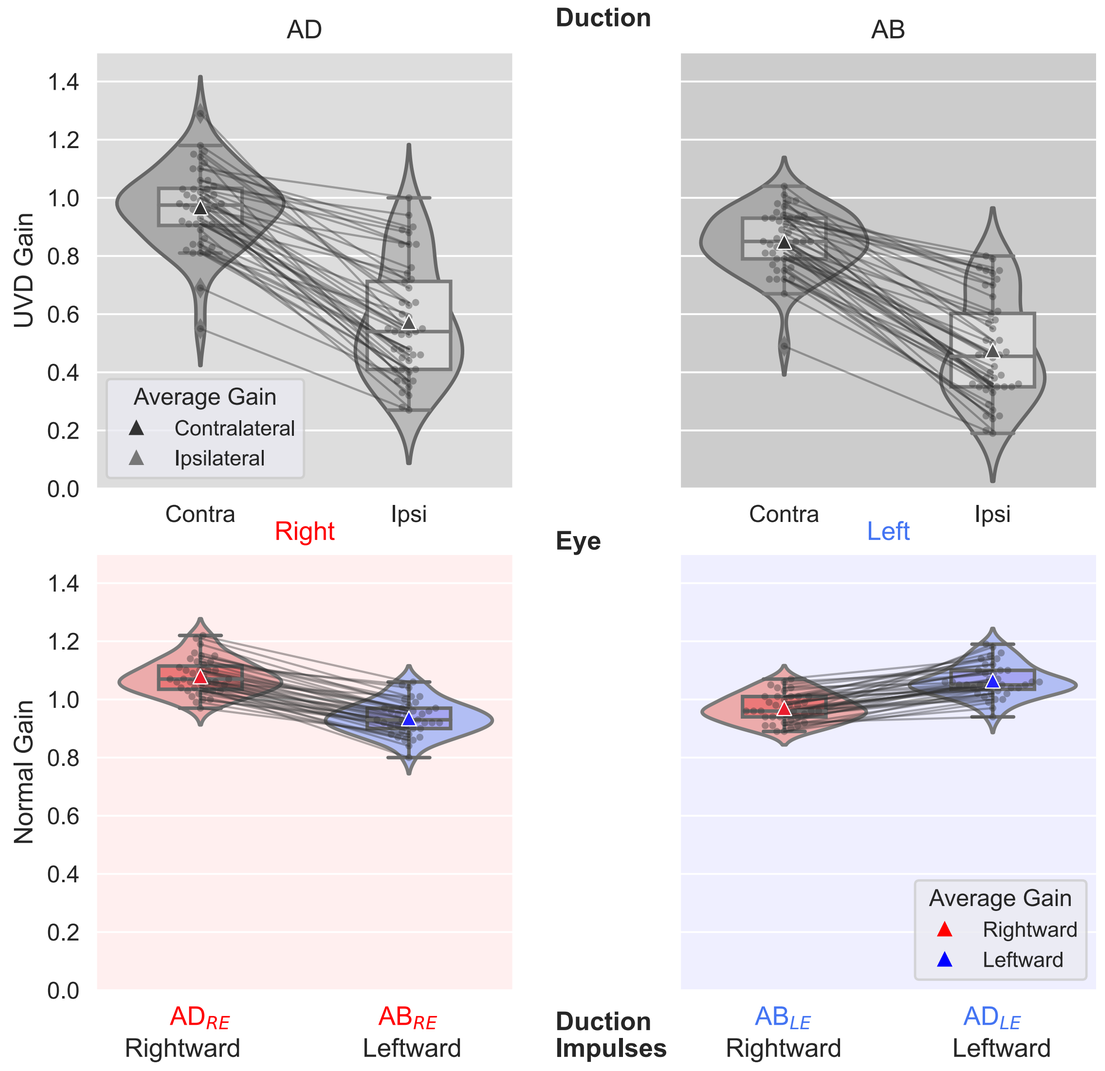


**Fig. 2:** Individual gain values, box plots of descriptive statistics, and distributions for the factors Side (Ipsi-, Contralateral), Eye (left, right) and Duction (ABduction, ADduction) and Direction (Leftward, Rightward). The results of the Regression gain are shown. Top: Unilateral Vestibular Deficit (UVD); Bottom: Healthy Controls

A

| | | Impulse direction | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | | Rightward | | | Leftward | | | |
| | | Rightward dysconjugacy ratio | Eye | | | | Leftward dysconjugacy ratio | |
| | | | Right | Left | Right | Left | | |
| | Equation | $AD_{RE}/AB_{LE}$ | $AD_{RE}$ | $AB_{LE}$ | $AB_{RE}$ | $AD_{LE}$ | $AD_{LE}/AB_{RE}$ | |
| Gain Method | **Regression** | **1.12 (0.05)** | **1.08 (0.06)** | **0.97 (0.05)** | **0.94 (0.06)** | **1.07 (0.06)** | **1.14 (0.05)** | Mean (SD) |
| | Instantaneous | 1.15 (0.08) | 1.03 (0.09) | 0.9 (0.09) | 0.86 (0.08) | 1.01 (0.08) | 1.18 (0.07) | |
| | Median | 1.10 (0.05) | 1.06 (0.06) | 0.96 (0.05) | 0.94 (0.06) | 1.06 (0.06) | 1.13 (0.05) | |
| | **Regression** | **[1.02; 1.22]** | **[0.96; 1.2]** | **[0.87; 1.07]** | **[0.82; 1.06]** | **[0.95; 1.19]** | **[1.04; 1.24]** | Range |
| | Instantaneous | [0.99; 1.31] | [0.85; 1.21] | [0.72; 1.08] | [0.70; 1.02] | [0.85; 1.17] | [1.04; 1.32] | |
| | Median | [1.00; 1.2] | [0.94; 1.18] | [0.86; 1.06] | [0.82; 1.06] | [0.94; 1.18] | [1.03; 1.23] | |
| | Metric | Rightward_vorDR | VOR Gain | | | | Leftward_vorDR | |

B

| | | VOR asymmetry index | | | |
|---|---|---|---|---|---|
| | | Monocular | | Binocular | |
| | | Eye | | Ductional VOR asymmetry index | |
| | | Right | Left | AD_vorDAI | AB_vorDAI |
| | Equation | $\lvert AD_{RE}-AB_{RE}\rvert/AD_{RE}+AB_{RE}$ | $\lvert AD_{LE}-AB_{LE}\rvert/AD_{LE}+AB_{LE}$ | $\lvert AD_{RE}-AD_{LE}\rvert/AD_{RE}+AD_{LE}$ | $\lvert AB_{RE}-AB_{LE}\rvert/AB_{RE}+AB_{LE}$ |
| Gain Method | **Regression** | **7.0 (2.8)** | **4.5 (3.0)** | **1.3 (1.3)** | **2.2 (2.8)** | Median (IQR) |
| | Instantaneous | 8.4 (3.8) | 5.7 (4.0) | 1.9 (1.9) | 2.0 (3.8) | |
| | Median | 5.6 (3.4) | 4.8 (3.8) | 2.0 (1.2) | 1.6 (2.2) | |
| | **Regression** | **[3.4; 11.3]** | **[0.9; 11.0]** | **[0.0; 4.3]** | **[0.0; 6.1]** | Range |
| | Instantaneous | [4.3; 15.6] | [1.0; 17.2] | [0.0; 6.6] | [0.0; 8.5] | |
| | Median | [1.5; 13.4] | [0.5; 8.8] | [0.0; 4.9] | [0.0; 8.1] | |
| | Metric | m-vorAI [%] | | vorDAI [%] | | |

**Table 1:** Normative data for gains and vorDR (A) and VOR asymmetry indices (B)

## Conclusions

Our study provides results from UVD patients and normative values reflecting the conjugacy of eye movement responses to horizontal bvHIT. The normal results were similar to a previous study using gold-standard scleral search coil, which also reported greater VOR gains in the adducting eye than the abducting eye. In analogy to the analysis of saccade conjugacy, we propose the use of a novel bvHIT dysconjugacy ratio to assess differences between adducting and abducting VOR eye movement responses. For an accurate assessment of VOR symmetry, it is recommended that asymmetry indices be used to compare the duction-related VOR gains recorded from both eyes.