

**MASTER VESTIBOLOGIA PRATICA
SECONDO LIVELLO
ANNO ACCADEMICO: 2017/2018
DIRETTORE: Prof. Giovanni Ralli**



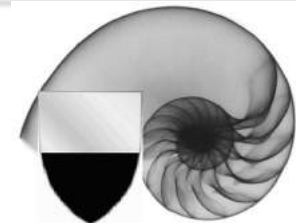
SAPIENZA
UNIVERSITÀ DI ROMA

THE FUNCTIONAL HEAD IMPULSE TEST (FHIT)

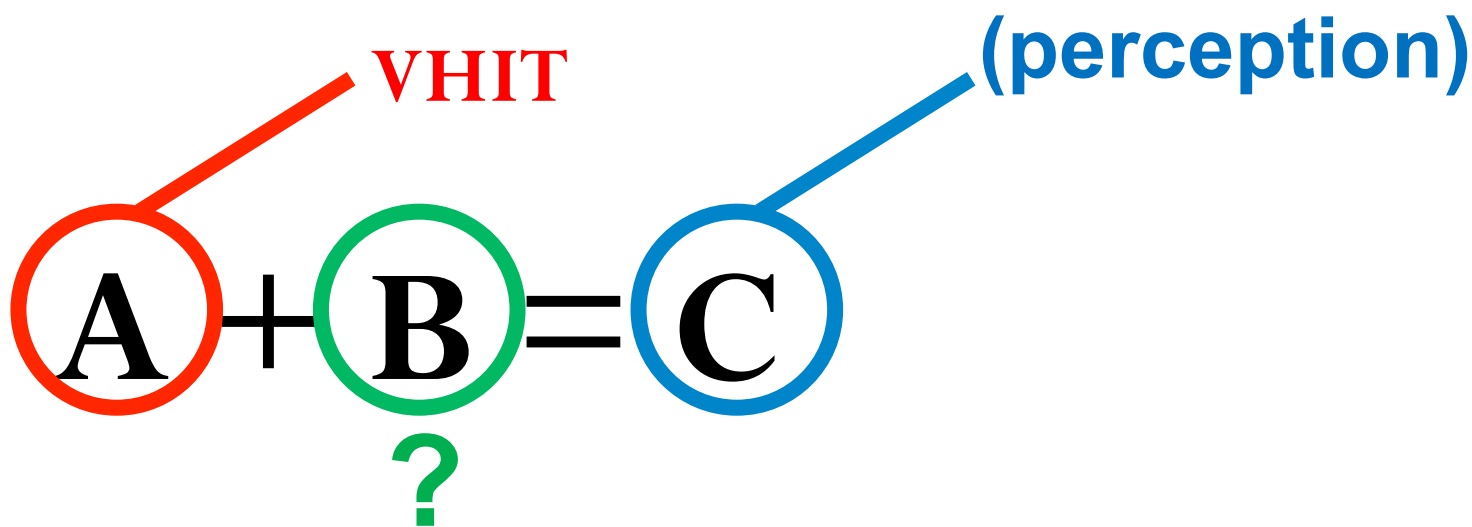
Marco Mandalà



Otology and Skull Base Surgery Department
University of Siena, Italy



In case you were the last audiologist on an remote island would you prefer to have with you the pure tone or speech audiometry?

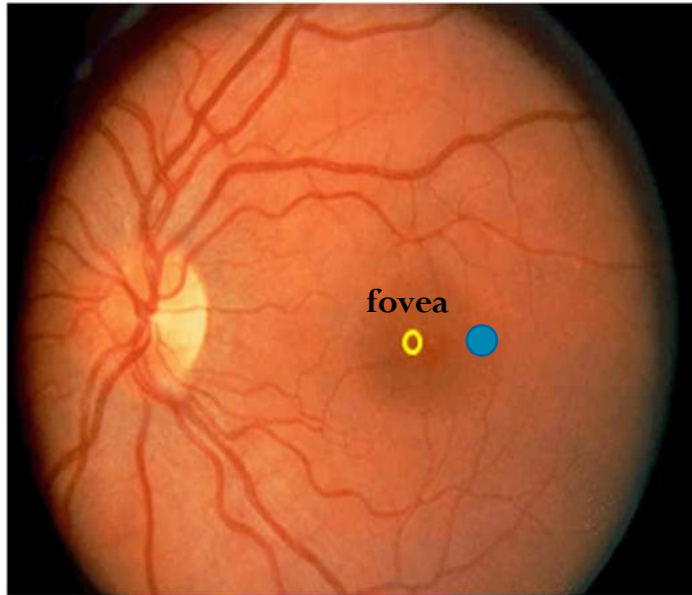


Vestibulo Ocular Reflex (VOR)

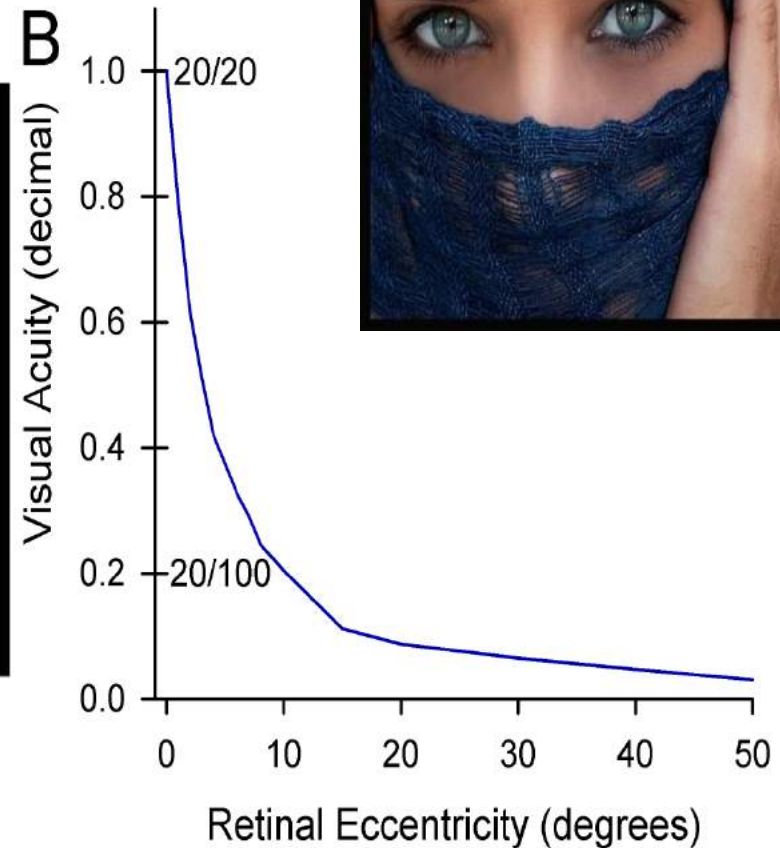
- VOR: enables clear vision by stabilizing gaze (eye position in space) during head movements (mediated by six SCCs)
- Locomotion: head movements with predominant high frequencies (0,5 to 5.0 Hz) and accelerations (4.000 deg/s² and above)
- VOR: rapidly acting reflex with short latency (7-15 ms) - fast enough to generate eye movements that compensate for these frequencies
- Latency of visual-mediated eye movements in humans too slow (75 ms)
- Function of the angular VOR: to hold images on the retina during head rotations... to allow perception!

Da Leigh &
Zee

A



B



Clear vision of an object requires that its image is held steadily within 0,5 deg from the center of the fovea (greatest photoreceptor density-optimal visual acuity)

2 degrees from the center of the fovea, visual acuity declines by about 50%.

VOR impairment

- *Poor gaze stabilization during head movements*
- *Impairment of vision when walking*
- *Dizziness / instability*



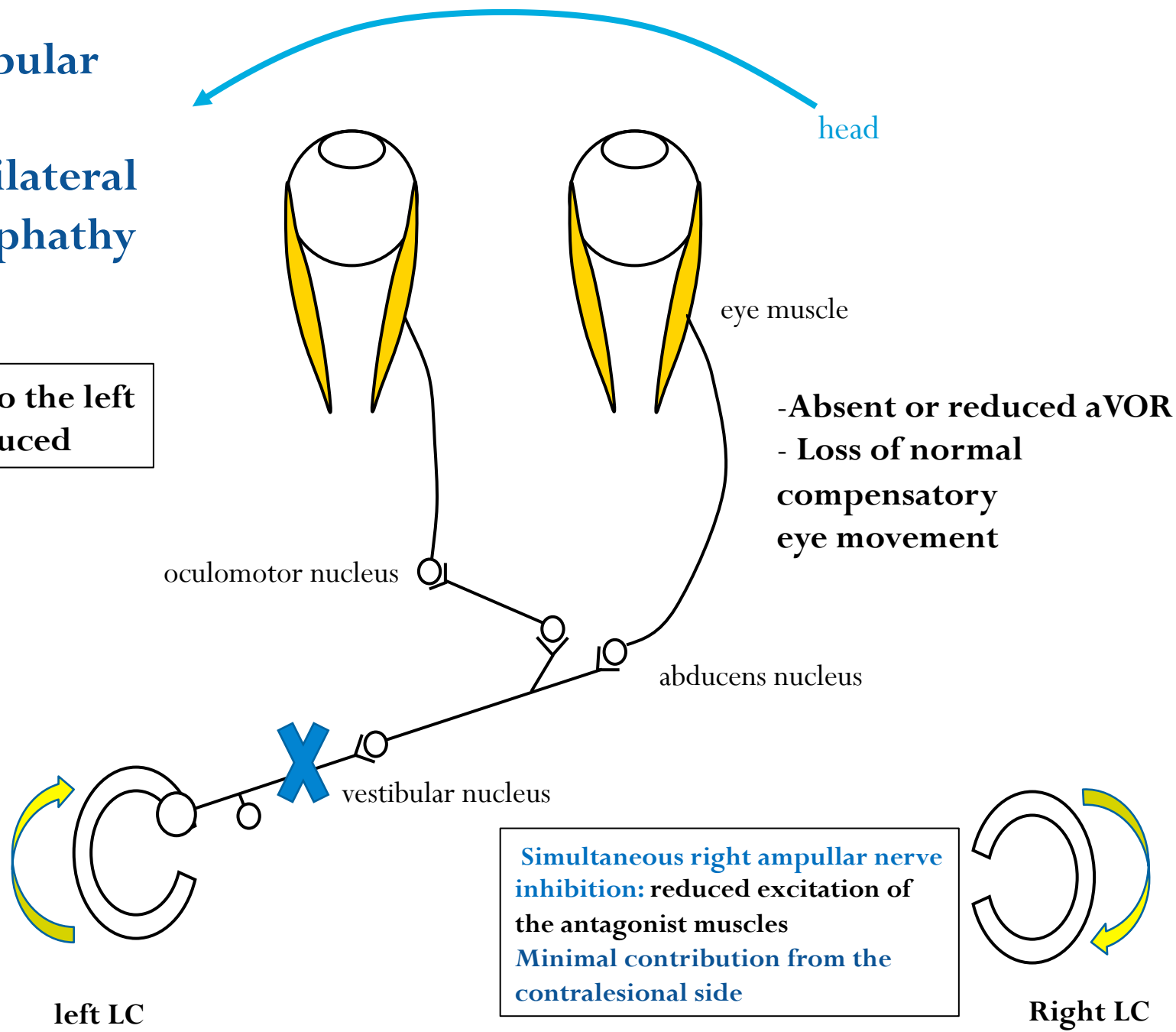
aVOR assessment: the HIT

- **A clinical sign of canal paresis.** (Halmagyi & Curthoys, Arch Neurol 1988)
- Revolution in the evaluation of vestibular disease
- Aw et al. (1996): scleral search coil HIT
- MacDougall et al.(2009): The Video HIT (Lightweight high speed video system – objective measurement)



Left vestibular neuritis – Acute unilateral vestibulopathy

-Head turn to the left is not transduced



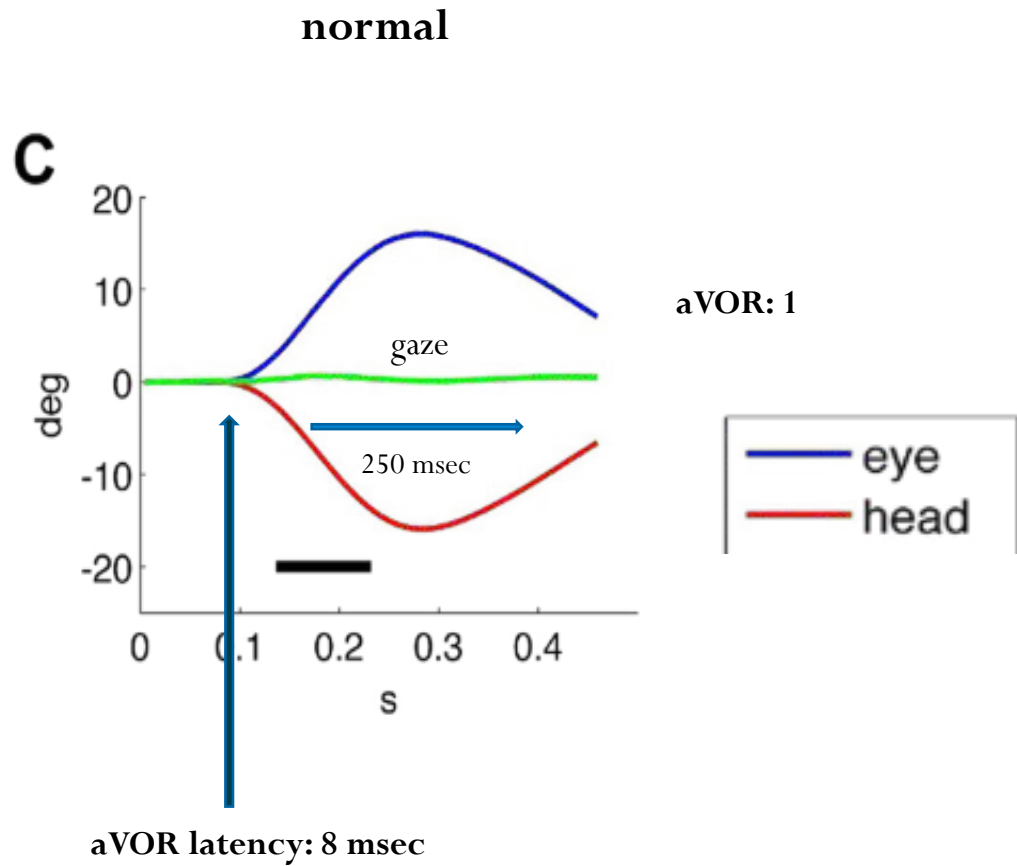
- Absent or reduced aVOR
- Loss of normal compensatory eye movement

Simultaneous right ampullar nerve inhibition: reduced excitation of the antagonist muscles
Minimal contribution from the contralesional side

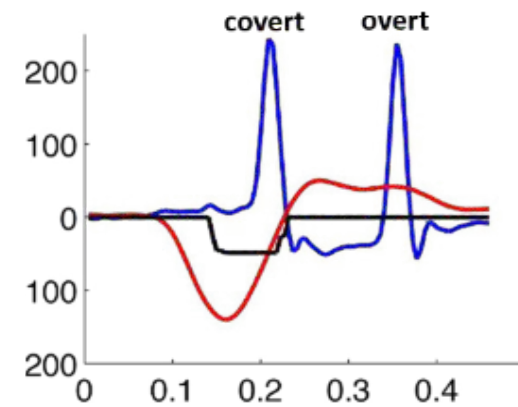
left LC

Right LC

Video HIT: ocular response (yaw axis)



Vestibular neuritis



Dynamic Visual Acuity Test



Normal subjects lose only 1 line of acuity with head shaking. Patients with no vestibular function lose about 5 lines with horizontal or vertical rotation but not with rotation in 'roll' (ear to shoulder) since the image is still on the fovea. Patients who lose DVA in 'roll' are malingering!

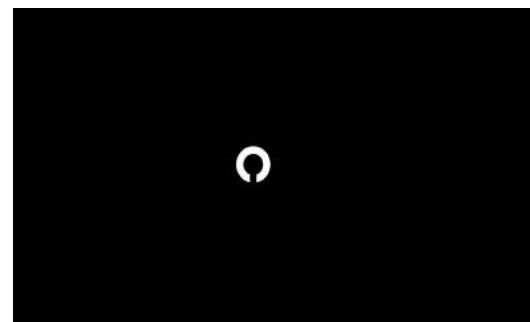
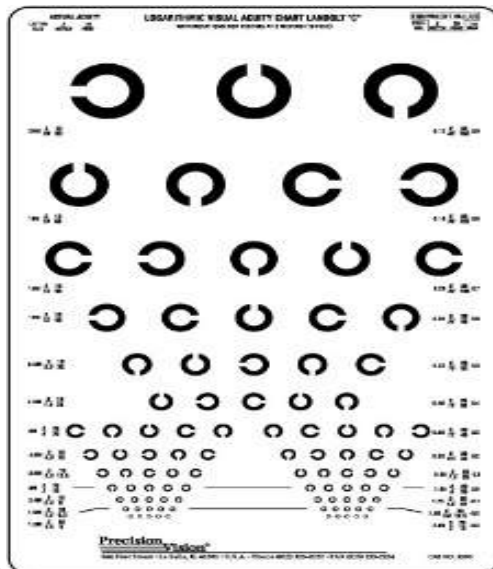
Functional HIT

- Perceptive test
- Does not measure the eye movements
- Assess the *function* of angular VOR at high acceleration/velocity
- Determines the ability to keep an image into focus when HIT is performed at different head accelerations and velocities

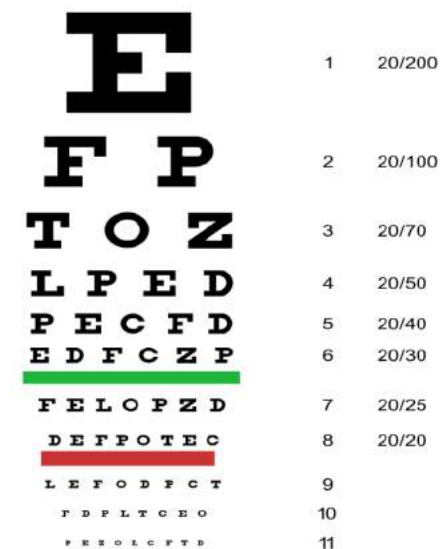
Functional HIT

- Measure of the ability to read an optotype briefly shown on the screen during head acceleration
- The patient must recognize the orientation of the Landolt C optotype with random orientation
- or a alphabet letter of the Snellen chart (Disney characters for children!)

Landolt C chart



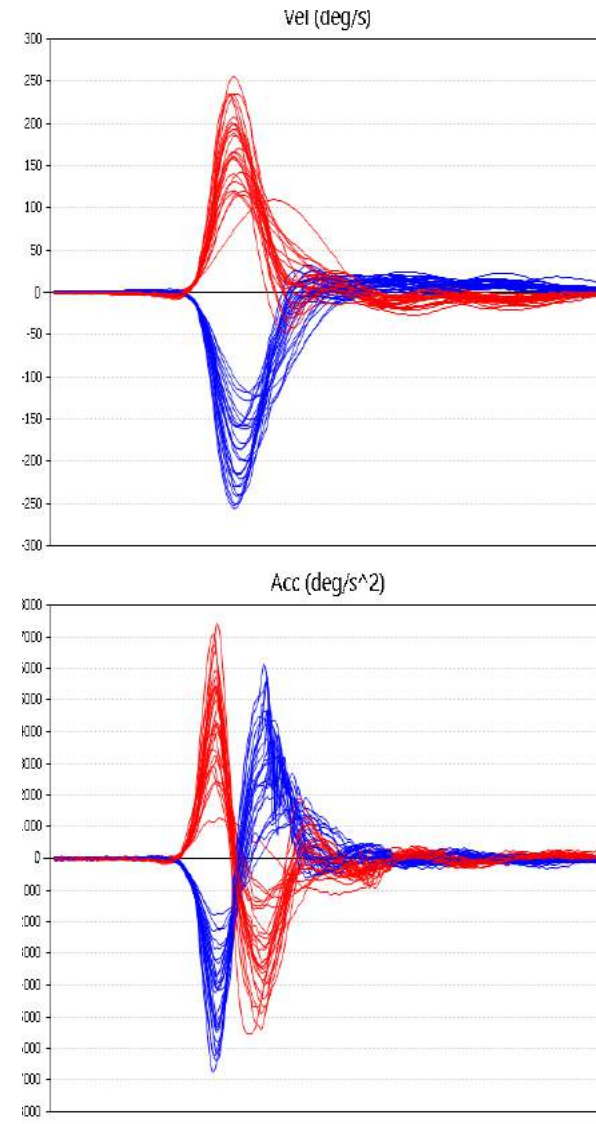
Snellen chart for visual acuity



Functional HIT

The **measure of static visual acuity** allows to normalize the size of the visual stimulus so that the letters shown were 0.6 logMAR lines larger.

The imposed head thrusts have different head accelerations, **classified in acceleration bins** (width of $1000^\circ / s^2$ with upper bounds ranging 2000–7000/ s^2) based on their direction.

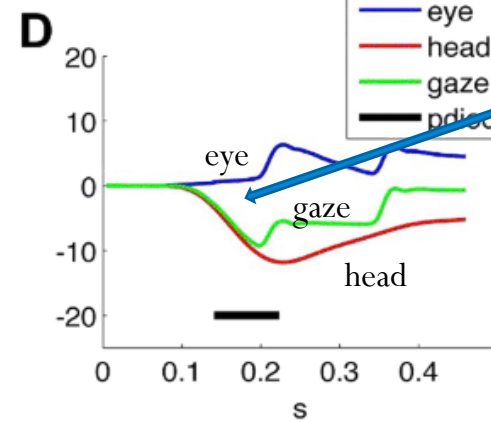
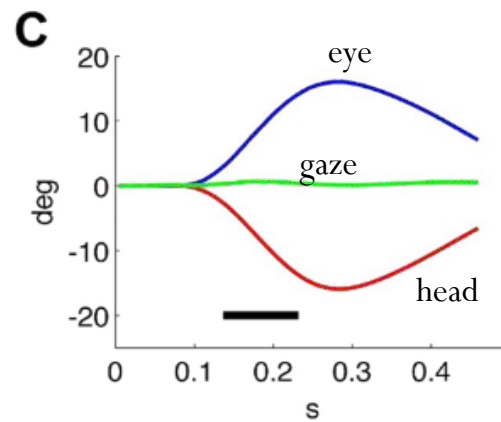
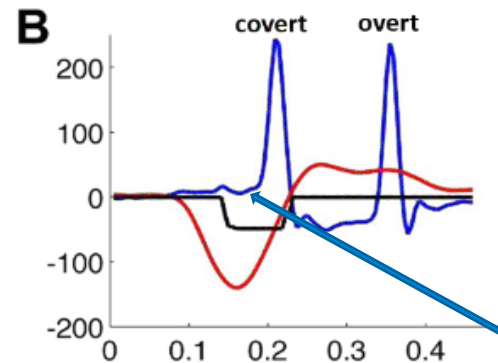
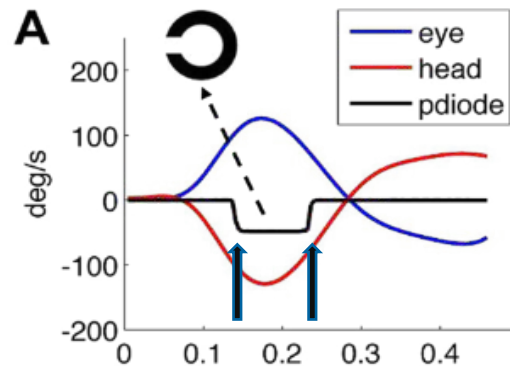


Functional Head Impulse Test (summary)

1. The **measure of static visual acuity** allows to normalize the size of the visual stimulus so that the letters shown were 0.6 logMAR lines larger.
2. An **optotype** with random orientation was shown during the head impulse based on head angular acceleration.
3. Patients were asked to recognize the shown letter.
4. Different head accelerations: the imposed head thrusts are **classified in acceleration bins** (width of $1000^\circ/s^2$ with upper bounds ranging 2000–7000/ s^2) based on their direction.

✓ Outcome % correct answers (Y axis) vs range of head accelerations (X axis).

fHIT



Impaired vision

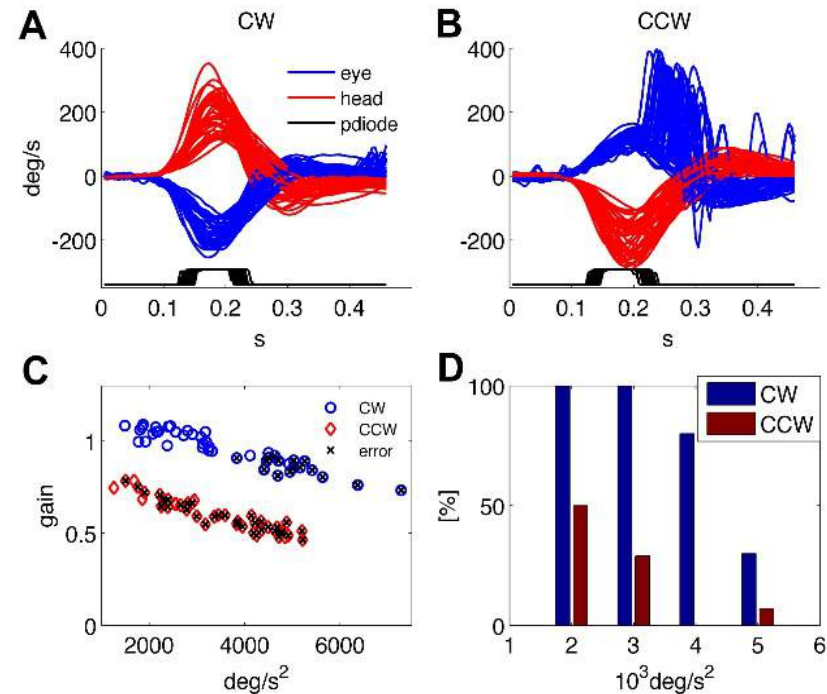
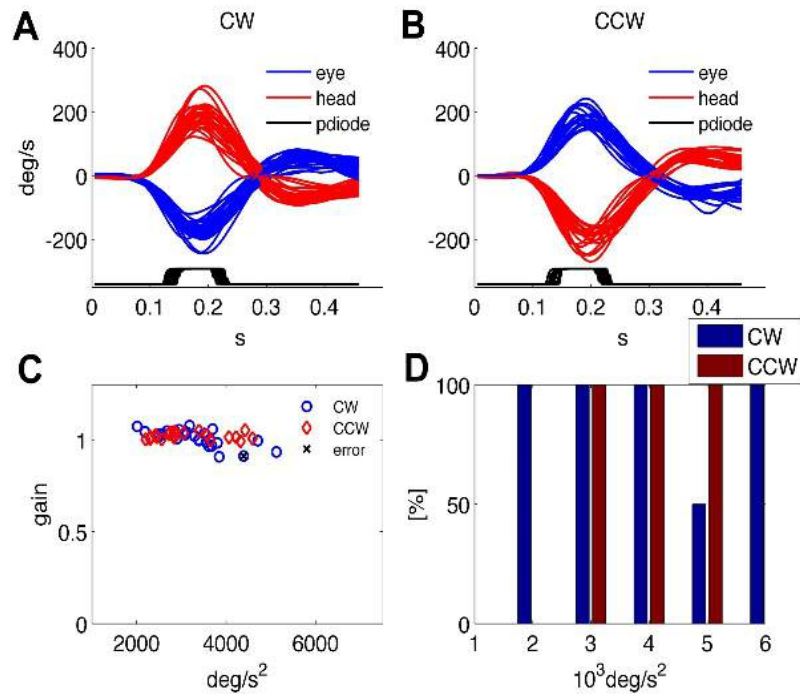
Optotype
presentation
period: around
80 msec

Colagiorgio et al. "A new tool for investigating the functional testing of the VOR". Front. Neurol. 4:165, 2013.

Validation with VHIT

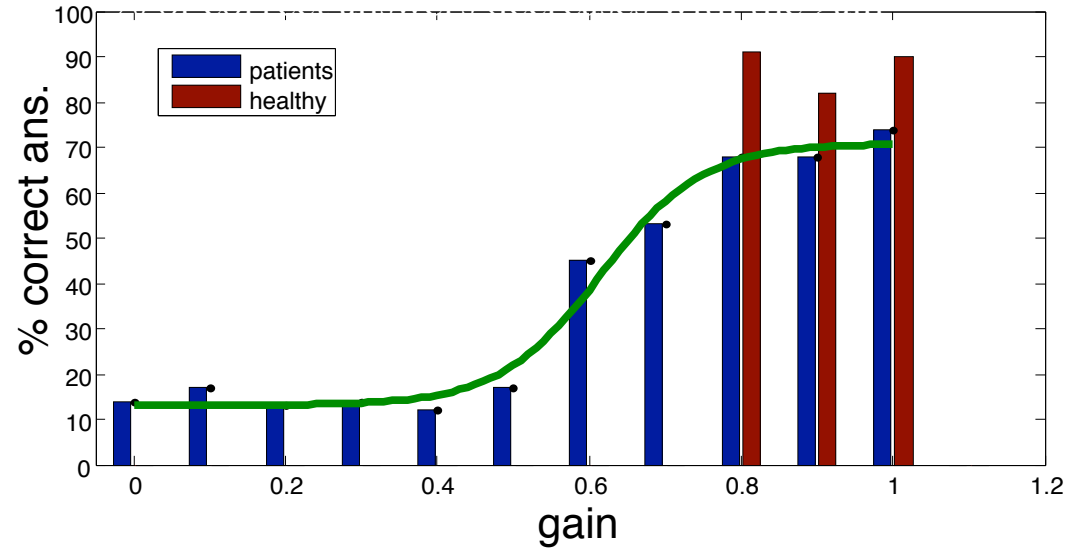
Healthy subject

Vestibular Neuritis – Acute Unilateral Vestibulopathy

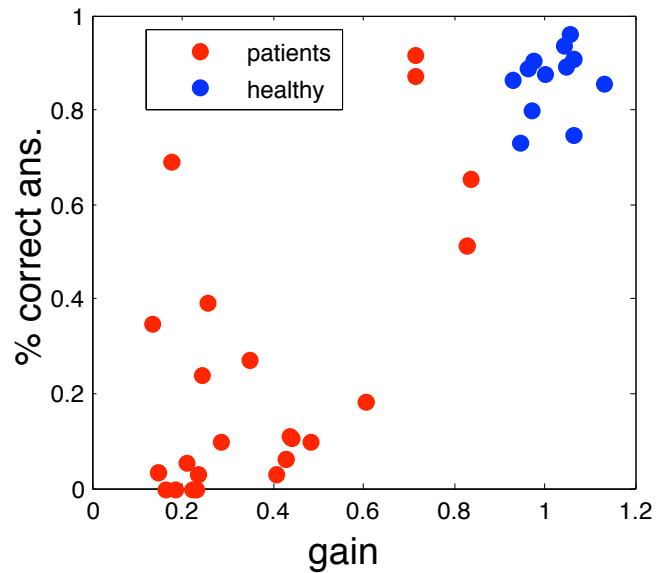


Versino M, Colagiorgio P, Sacco S, Colnaghi S, Quagliari S, Manfrin M, Benazzo M, Moglia A, Ramat (2014) *S. Reading while moving: The functional assessment of VOR*. Journal of Vestibular Research, 24(5).

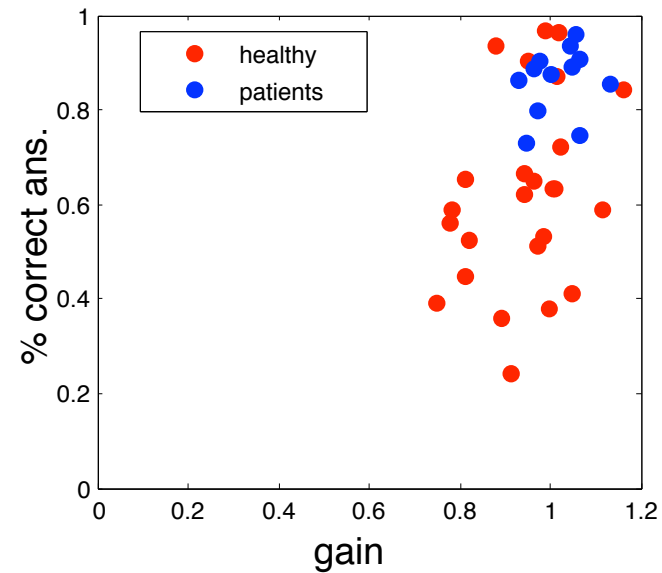
Validation with VOG



Ipsilateral



contralateral



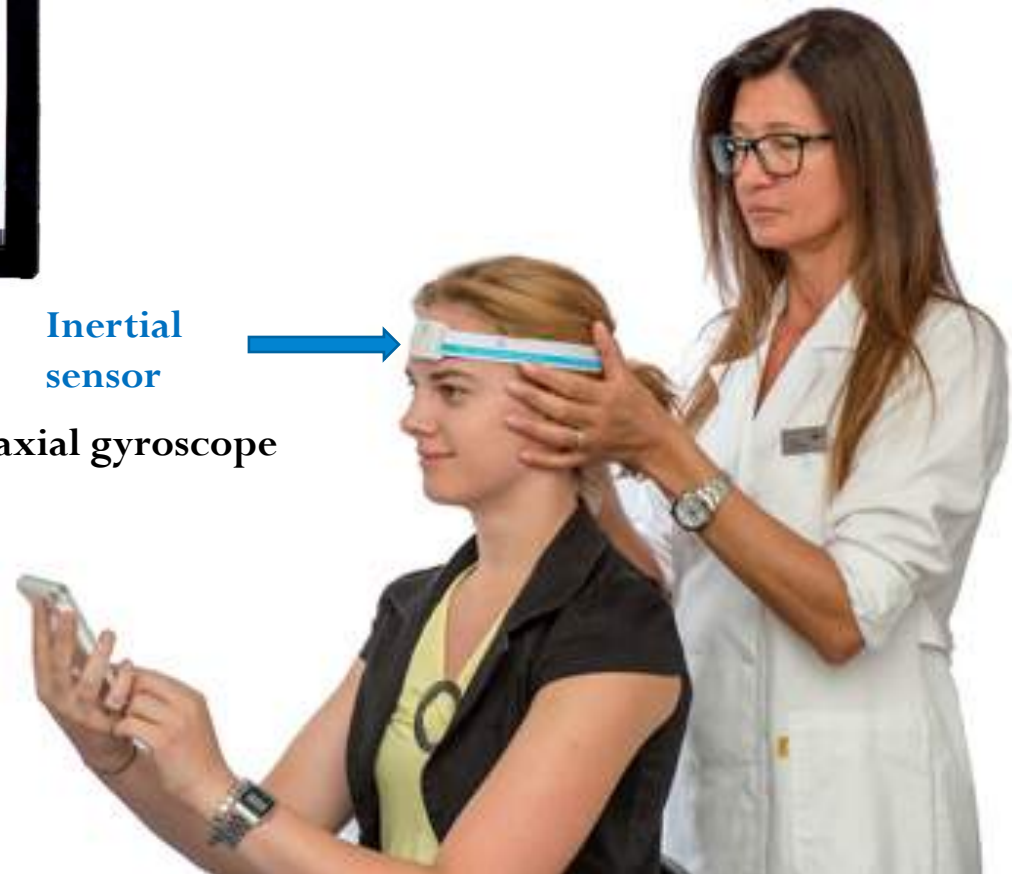
Functional Head Impulse Test



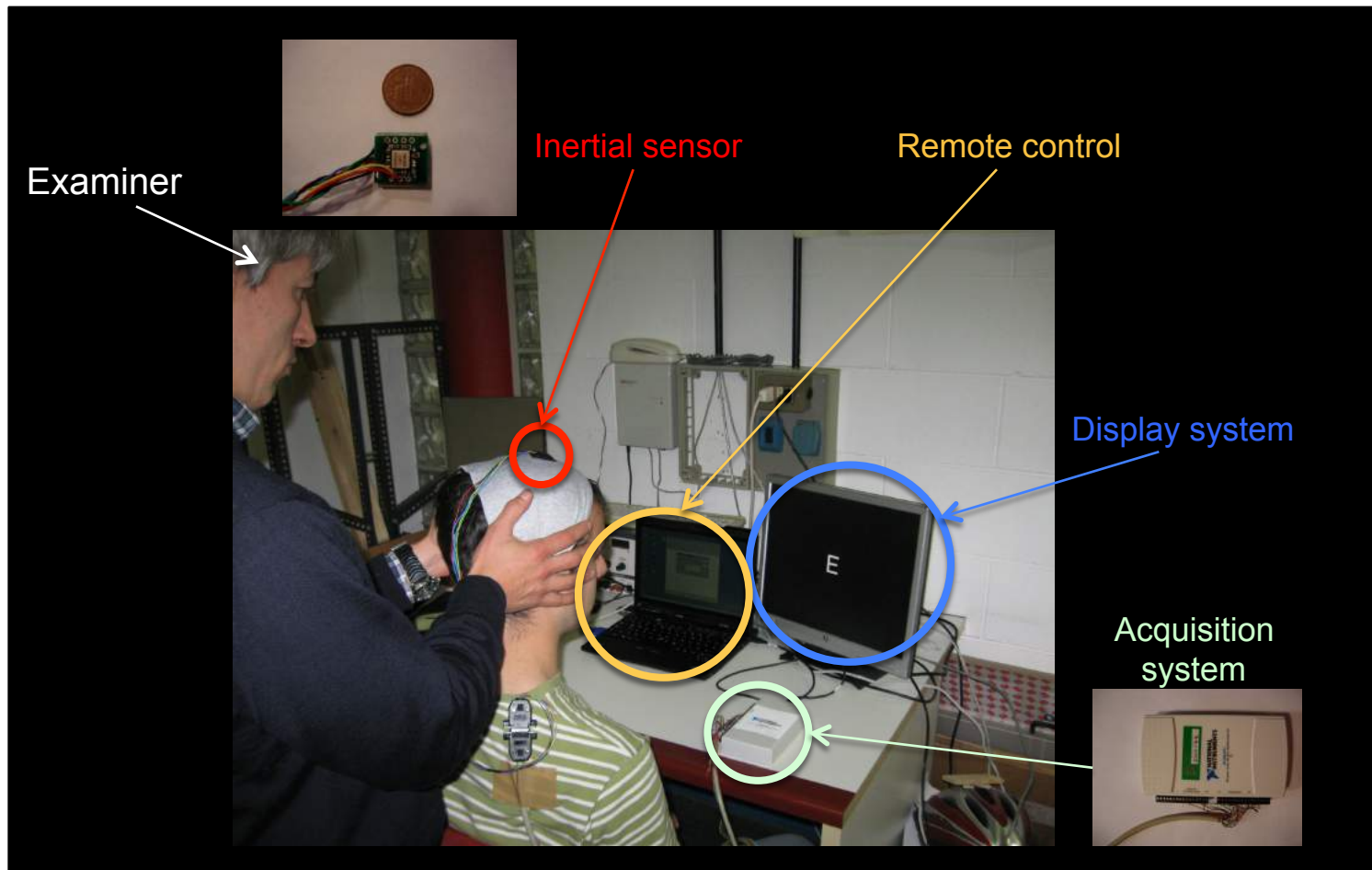
Inertial
sensor



3 axial gyroscope



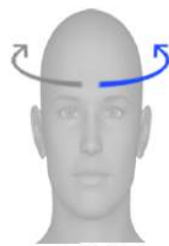
FHIT: FUNCTIONAL HEAD IMPULSE TEST ...the beginning





FHIT

Test Outcome = % correct answers

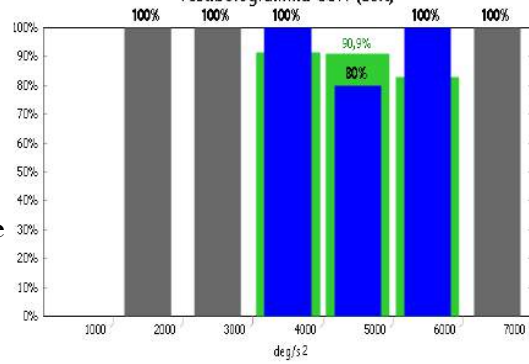


CCW (Left)

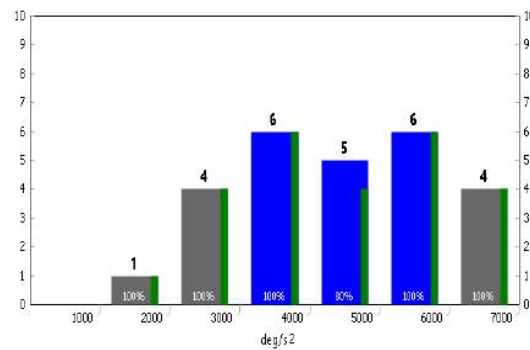
Tot Movimenti:
17/30

Risposte OK:
94,1% [89,6%]

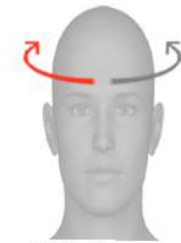
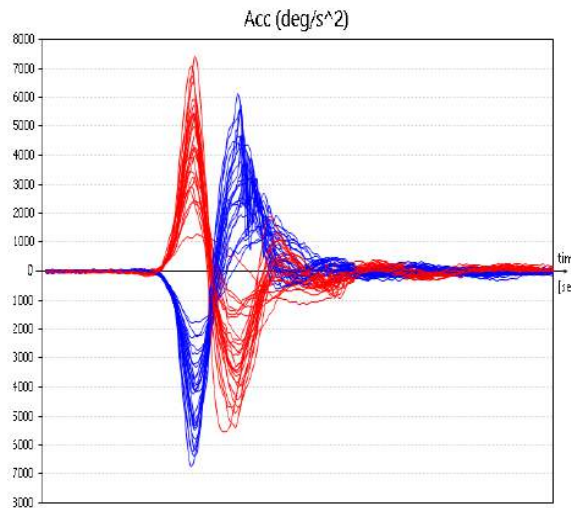
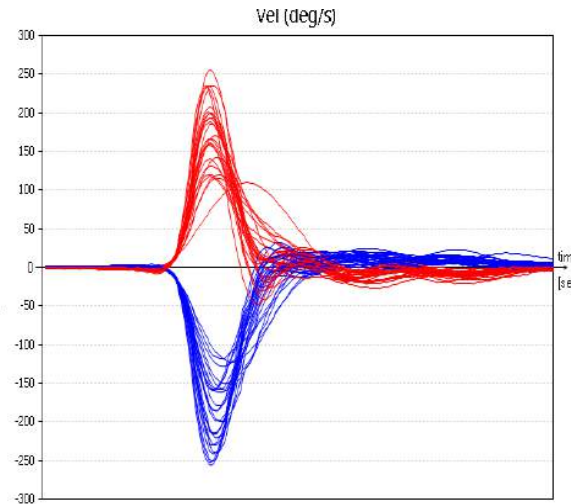
Vestibologramma CCW (Left)



Contatore Movimenti CCW (Left)



Diagnosi CCW: Z = -0,417

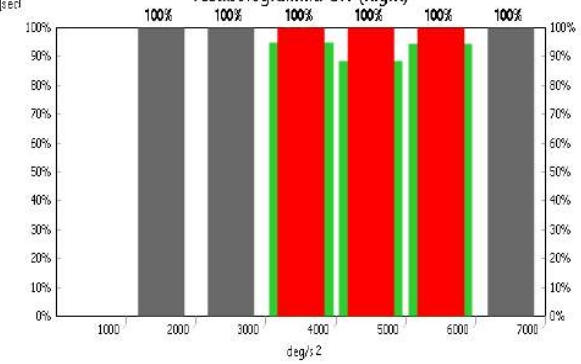


CW (Right)

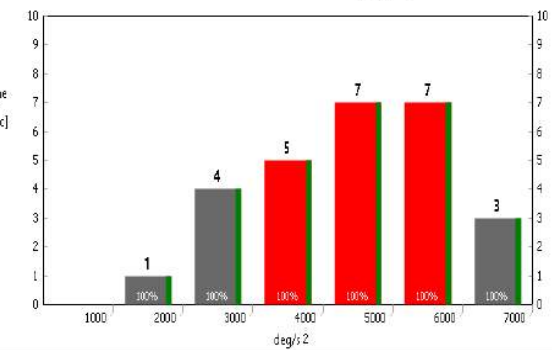
Tot Movimenti:
18/30

Risposte OK:
100,0 [92,9%]

Vestibologramma CW (Right)



Contatore Movimenti CW (Right)



Diagnosi: Z = -1,258

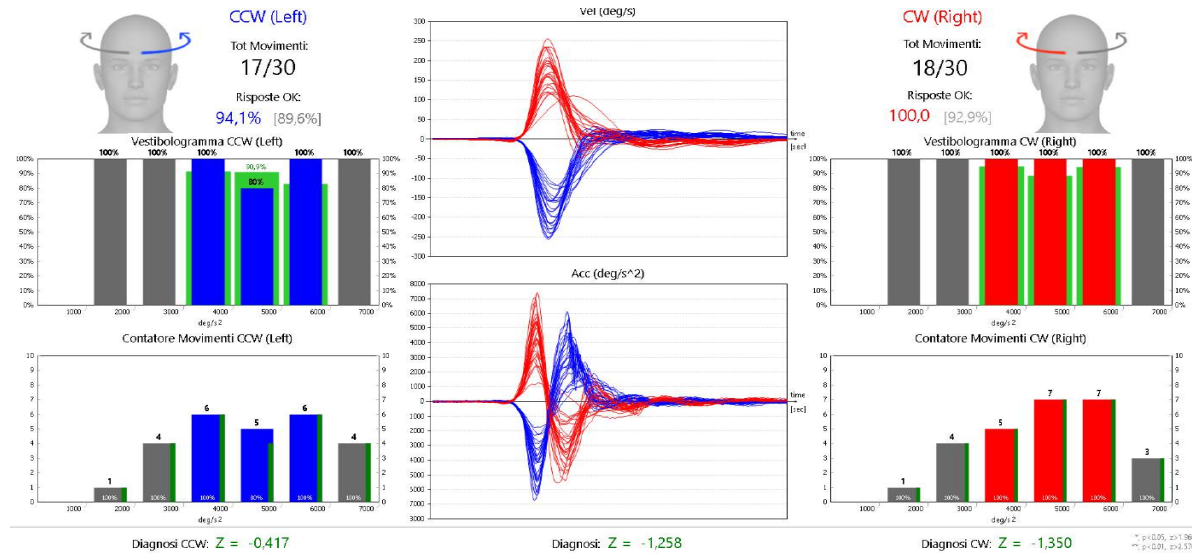
Diagnosi CW: Z = -1,350

* p < 0,05, z > 1,960
** p < 0,01, z > 2,576

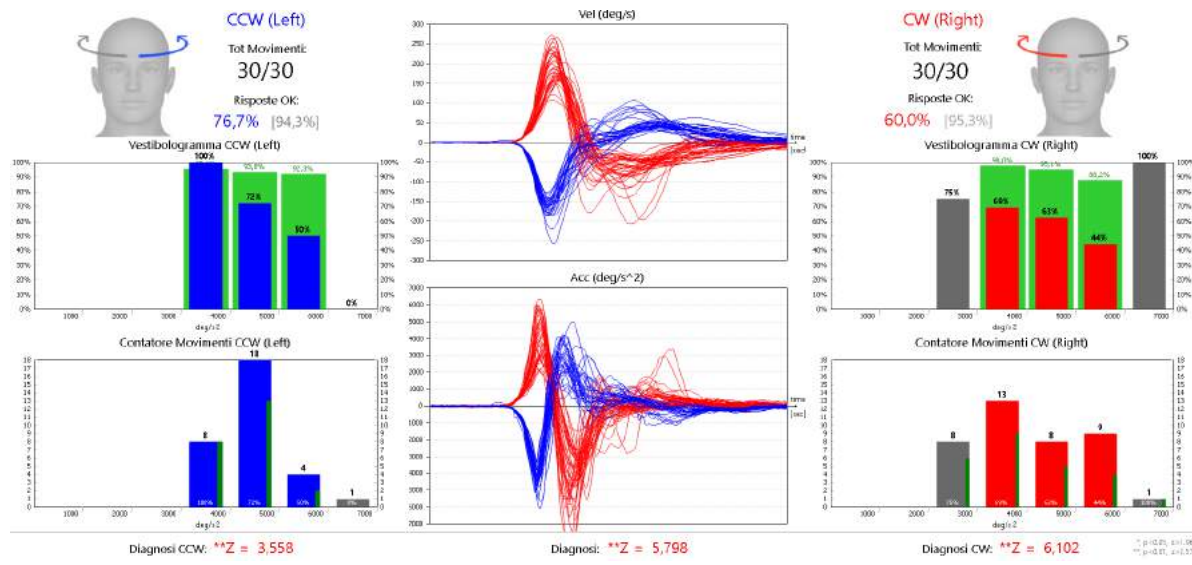
Score
Percentage
of correct re
sponses

N° head
impulses

Functional Head Impulse Test



Healthy subject



Patient

Conclusions

- FHIT is a complementary test to assess vestibular function (like speech audiometry and pure tone audiometry)
- Does not require eye movements analysis
- Easy and fast (10 minutes) – patient clear insight of the disorder
- Paediatric patients
- “Small eyes” people
- With glasses (?)
- Good correlation with patient perception of the disorder (bilateral VL...)
- New perspectives: vestibular neuropathy, presbiastasis, vestibular migraine...
- Rehabilitation



Stefano Ramat

**Functional
Head
Impulse
Test**



Marco
Mandalà

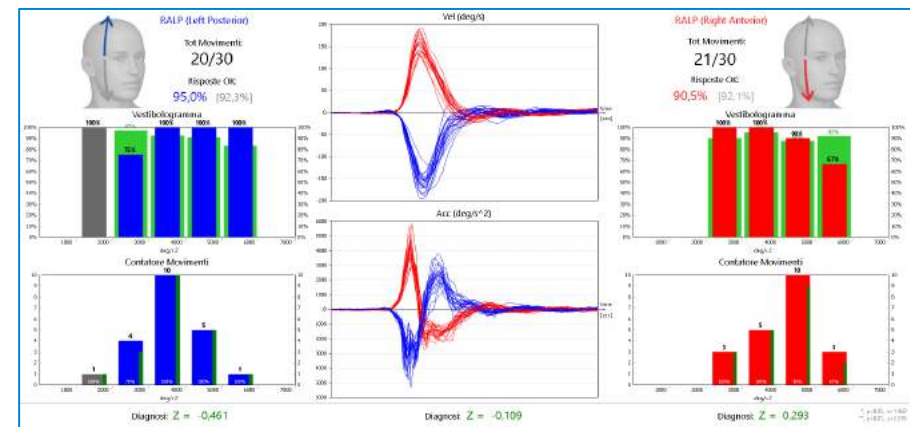
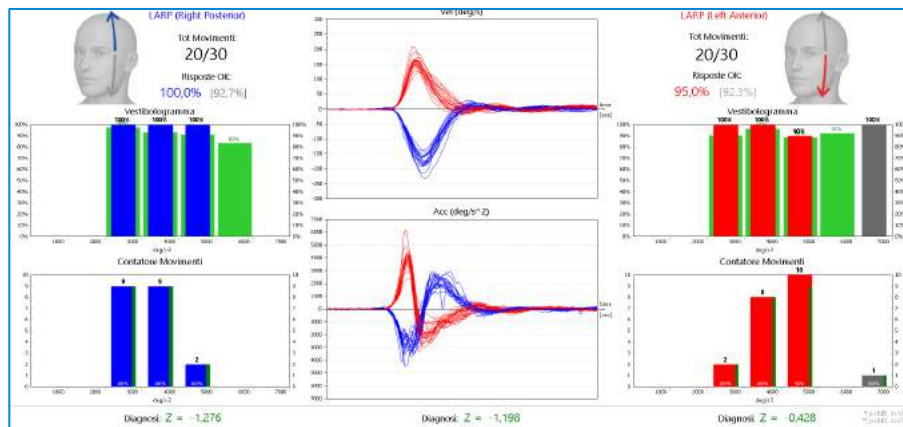


Maurizio
Versino



LARP

RALP



LEFT ACUTE VESTIBULAR NEURITIS

Data referto: 15/05/2017

Operatore referto: utente utente

Impulso della testa

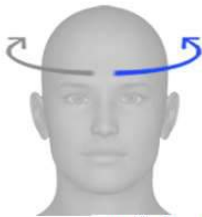
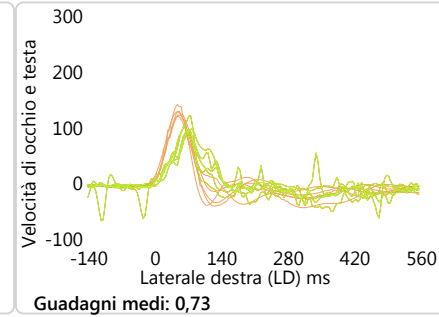
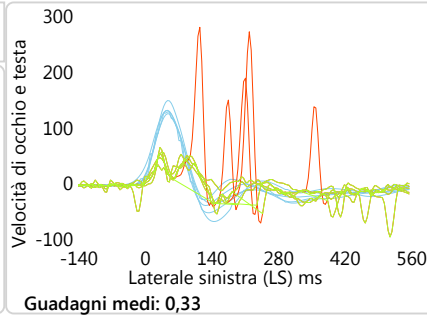
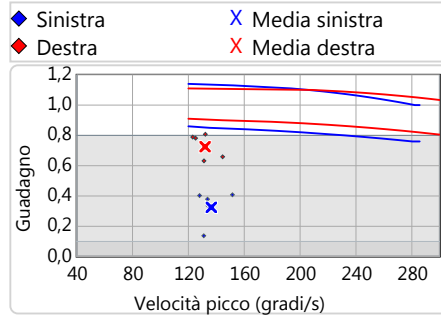
Prova impulso laterale: 05/04/2017 12:02:32

Operatore della prova: utente utente

\bar{x} Sinistra: 0,33, σ : 0,1

\bar{x} Destra: 0,73, σ : 0,07

Asimmetria relativa: 55%

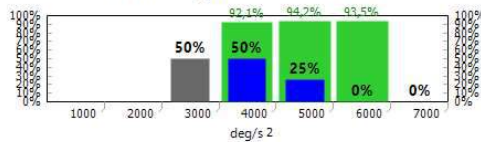


CCW (Left)

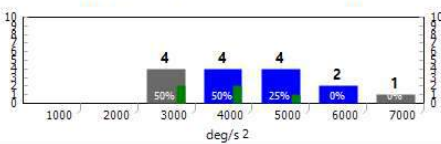
Tot Movement:
10/30

Answers OK:
30,0% [93,3%]

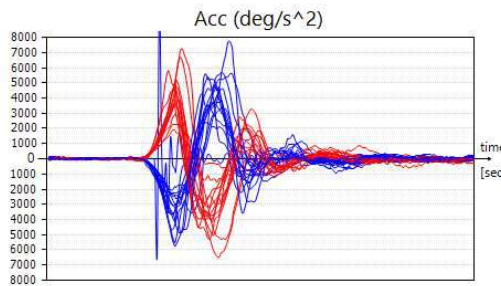
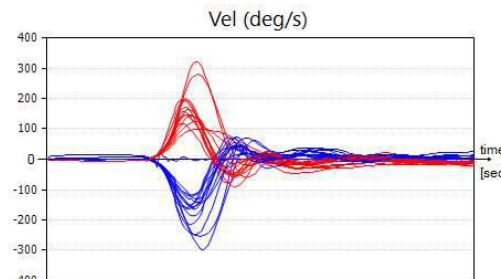
Vestibologramma CCW (Left)



Movement Counter CCW (Left)



Diagnosis CCW: ****Z = 7,624**



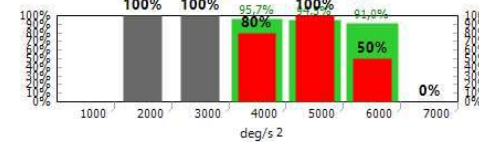
Diagnosis: ****Z = 6,413**

CW (Right)

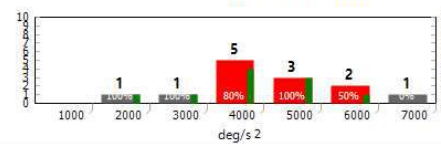
Tot Movement:
10/30

Answers OK:
80,0% [94,0%]

Vestibologramma CW (Right)



Movement Counter CW (Right)



Diagnosis CW: **Z = 1,726** ^{*}p<0,05, z>1,960 ^{**}p<0,01, z>2,576

LEFT ACUTE VESTIBULOPHATY (FOLLOW-UP 3 MONTHS)

Data referto: 15/05/2017

Operatore referto: utente utente

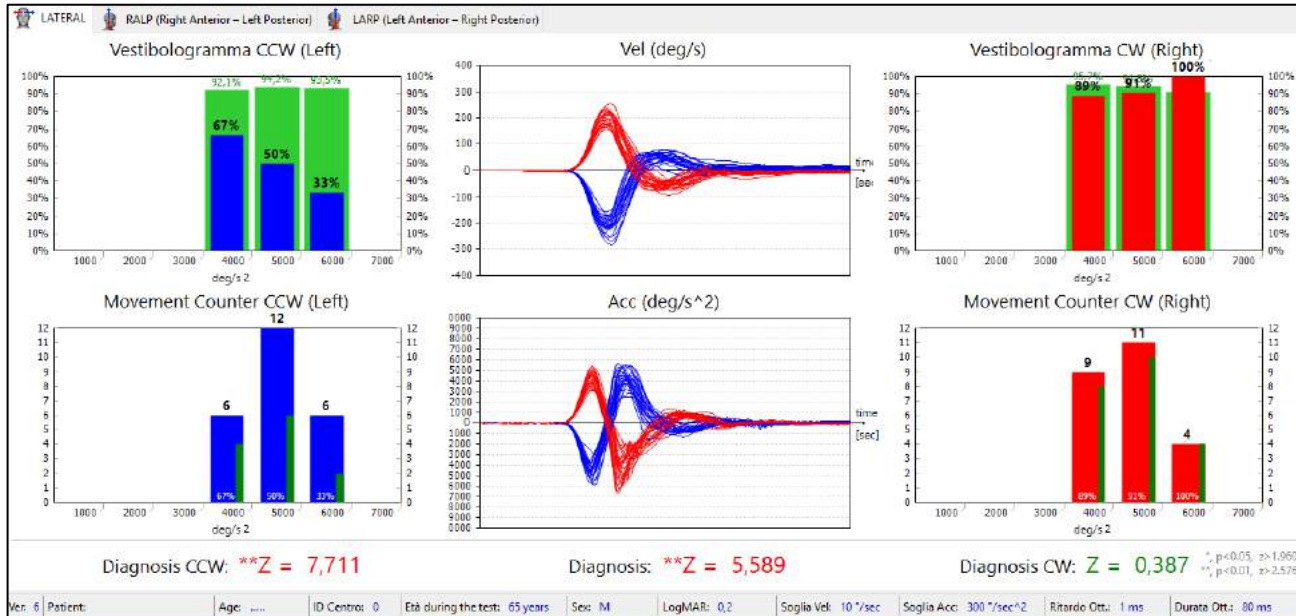
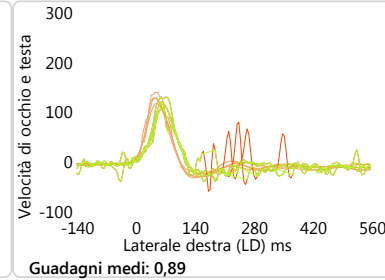
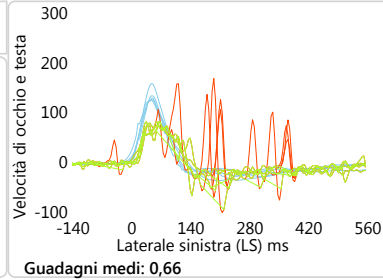
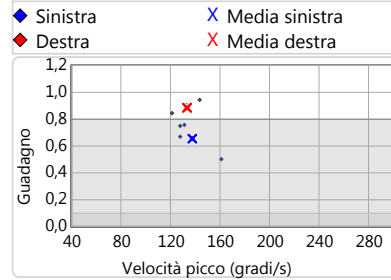
Impulso della testa

Prova impulso laterale: 26/04/2017 11:08:35
Operatore della prova: utente utente

\bar{x} Sinistra: 0,66, σ : 0,09

\bar{x} Destra: 0,89, σ : 0,04

Asimmetria relativa: 26%



LEFT VESTIBULAR NEURITIS 6 MONTHS FOLLOW-UP (RECOVERY)

Data referto: 15/05/2017

Operatore referto: utente utente

Impulso della testa

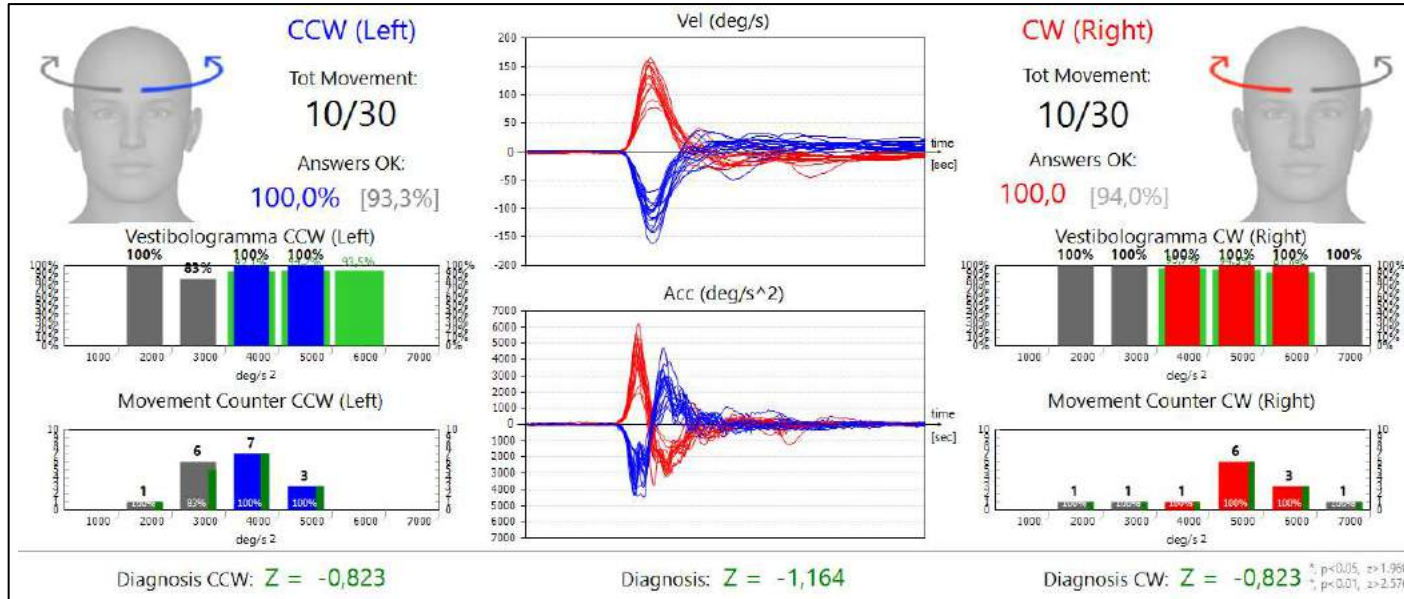
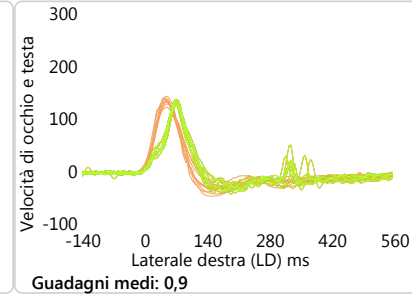
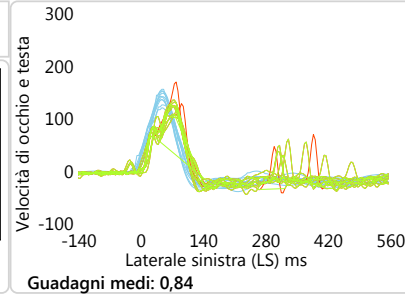
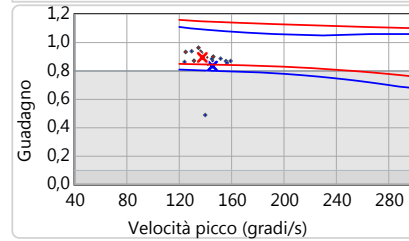
Prova impulso laterale: 05/04/2017 11:26:03
Operatore della prova: utente utente

\bar{x} Sinistra: 0,84, σ : 0,12

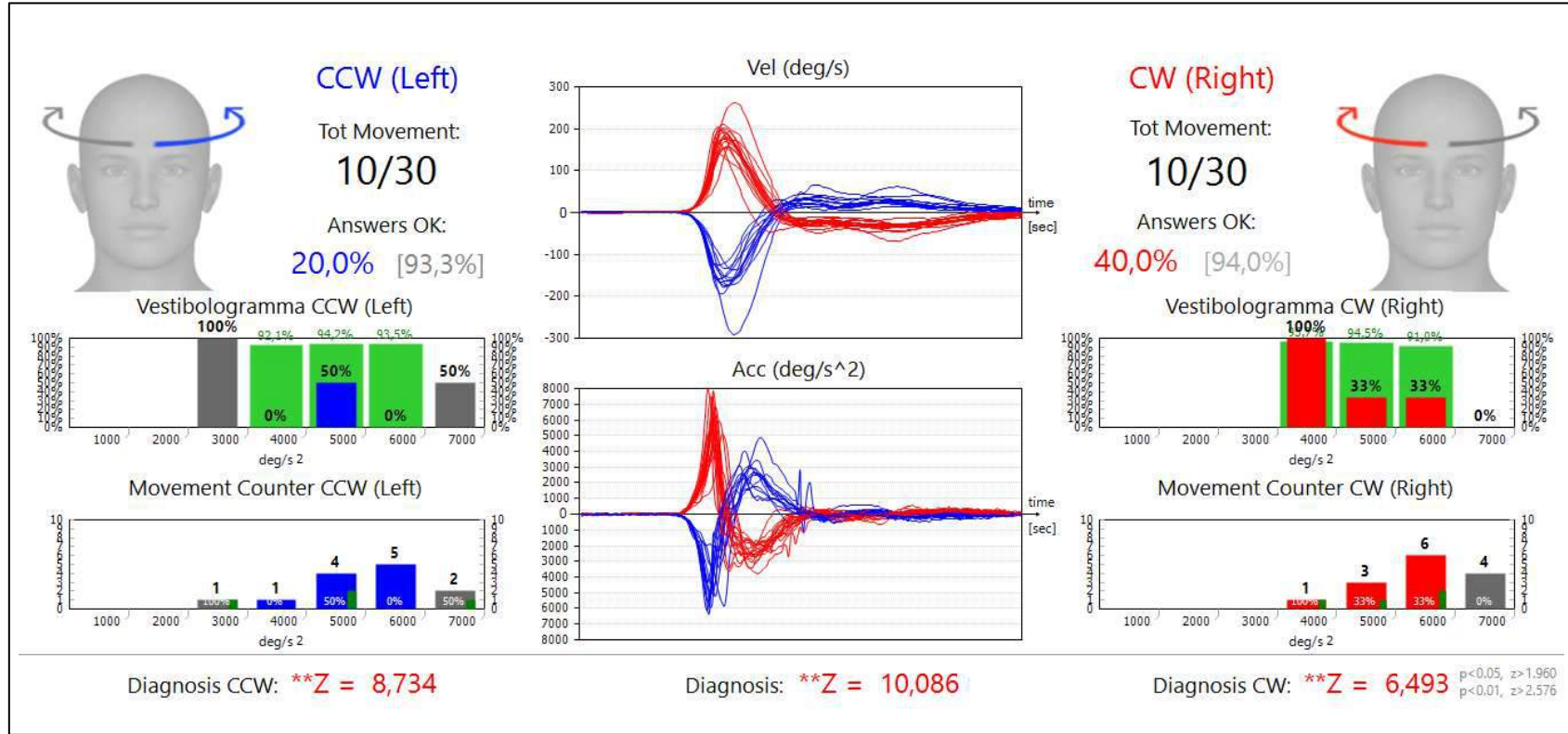
\bar{x} Destra: 0,9, σ : 0,03

Asimmetria relativa: 7%

◆ Sinistra X Media sinistra
◆ Destra X Media destra



BILATERAL VESTIBULAR LOSS



FHIT IN CHILDREN



Examintion: Spont. ny, Calorics, HST, HIT, HHT, Vibr,
VHIT, FHIT, DHI

N° subjects: 25

Sex (M/F): 13/12

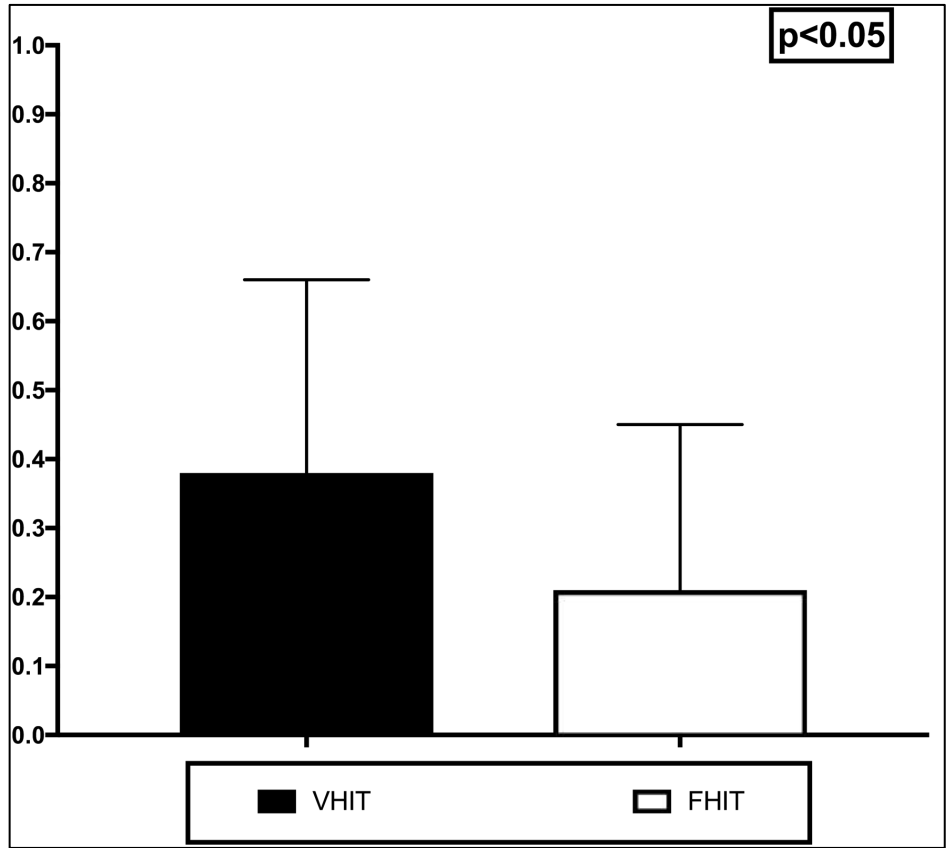
Age (years): 55.6±12.1

Side (R/L): 11/14

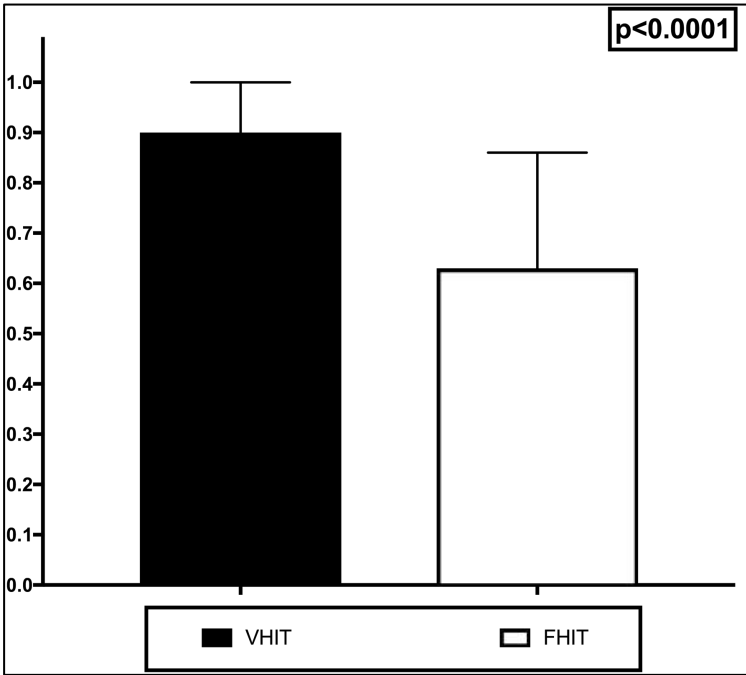
Follow-up: acute, 3 months

ACUTE

IPSI LESIONAL SIDE

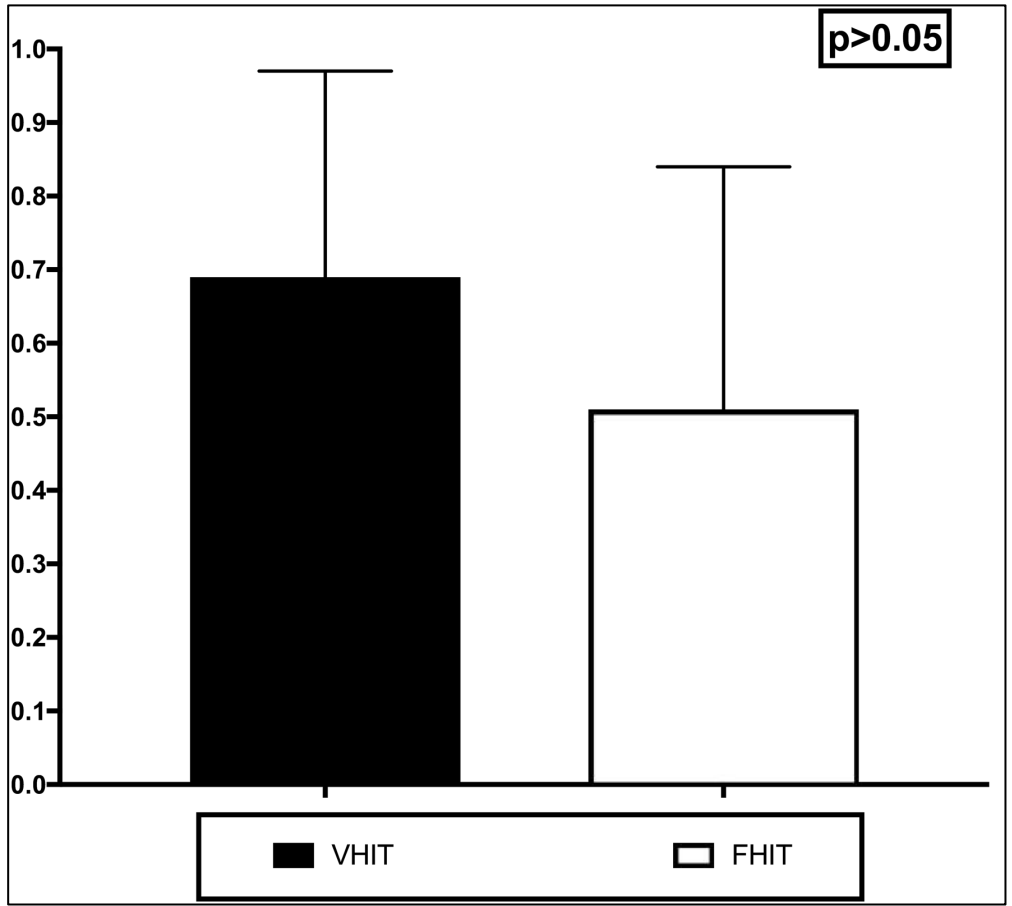


CONTRA LESIONAL SIDE

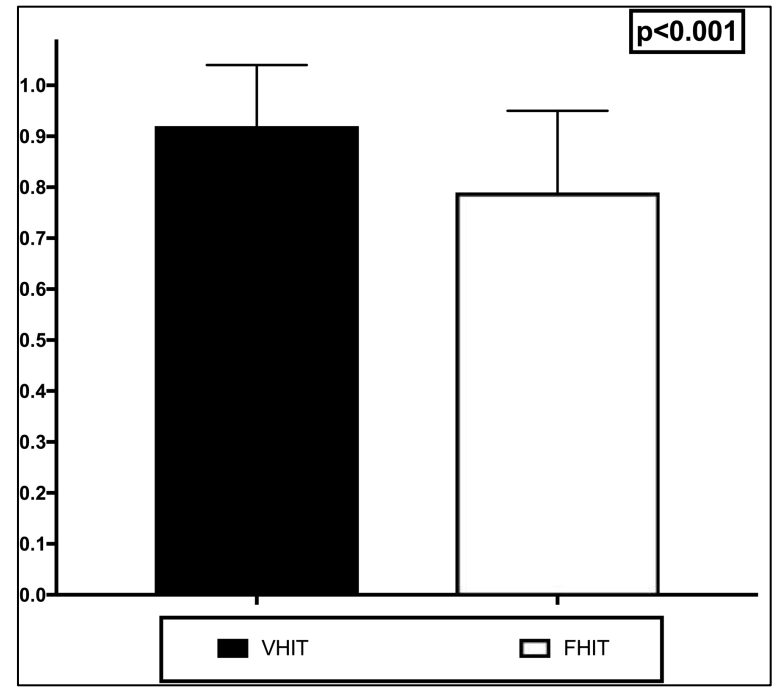


3 MONTHS FOLLOW-UP

IPSI LESIONAL SIDE



CONTRA LESIONAL SIDE

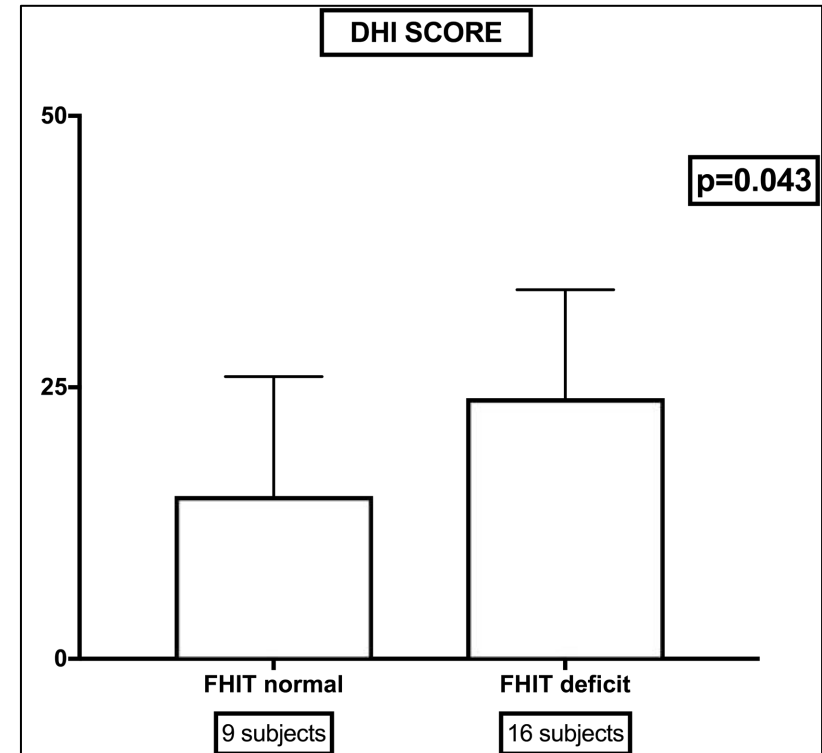
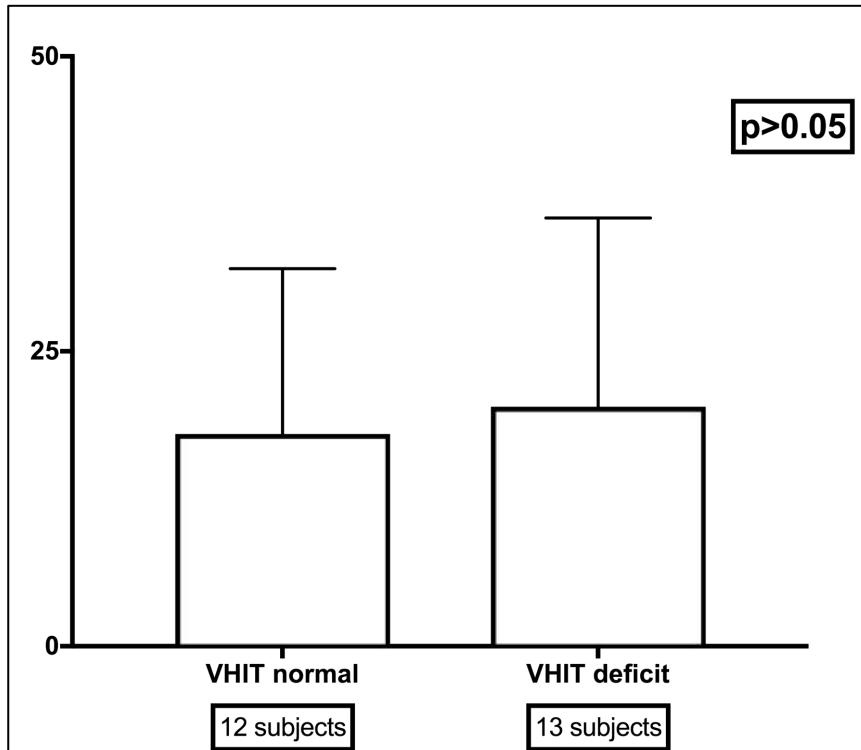


DHI TOTAL SCORE

3 MONTHS FOLLOW-UP

VHIT

FHIT



NUMBER OF SUBJECTS THAT COULD IDENTIFY THE PATHOLOGICAL SIDE DUE TO DIFFICULTIES AT VHIT AND FHIT AT 3 MONTHS

5/25 VHIT (20%)

16/25 FHIT (64%)

($p = 0.0037$, Fisher's test).

DISCUSSION

- **The VHIT and FHIT have similar results in acute and at 3 months follow-up despite contralesional side appears to be slightly more affected at FHIT**
- **5 subjects who showed covert saccades were correctly identified by the FHIT**
 - **The FHIT shows a stronger correlation with DHI (perceived disability) than VHIT (McCaslin et al. 2014; Patel et al., 2016)**
 - **Artifacts are not present in the FHIT while it is not an objective test**

Vestibular migraine ?

- Recognized as early as at the end of the XIX century
- Lack of agreement on diagnosis among the headache and the vestibular communities
- Consensus reached 2012 with the publication of the joint consensus of the Bárány Society and the International Headache Association

Journal of Vestibular Research 22 (2012) 167–172
DOI 10.3233/VES-2012-0453
IOS Press

167

Vestibular migraine: Diagnostic criteria

Consensus document of the Bárány Society and the International Headache Society

Thomas Lempert^{a,*}, Jes Olesen^b, Joseph Furman^c, John Waterston^d, Barry Seemungal^e, John Carey^f, Alexander Bisdorff^g, Maurizio Versino^h, Stefan Eversⁱ and David Newman-Toker^j

^aDepartment of Neurology, Schlosspark-Klinik, Berlin, Germany

^bDanish Headache Center and Department of Neurology, University of Copenhagen, Copenhagen, Denmark

^cDepartments of Otolaryngology and Newology, University of Pittsburgh, Pittsburgh, PA, USA

^dDepartment of Neurology and Monash University Department of Medicine, Alfred Hospital, Melbourne, Australia

^eDepartment of Clinical Neuroscience, Charing Cross Hospital, London, UK

^fDepartment of Otolaryngology, Head and Neck Surgery, Johns Hopkins University School of Medicine, Baltimore, MD, USA

^gDepartment of Neurology, Centre Hospitalier Emile Mayrisch, Esch-sur-Alzette, Luxembourg

^hDepartment of Neurological Sciences University of Pavia, HSC and BCC National Neurological Institute IRCCS

C. Mondino Foundation, Pavia, Lombardy, Italy

ⁱDepartment of Neurology, University of Münster, Münster, Germany

^jDepartment of Neurology, Johns Hopkins University School of Medicine, Baltimore, MD, USA

Diagnosis

- The consensus document provides diagnostic criteria based on
 - recurrent vestibular symptoms with a history of migraine,
 - temporal association of vestibular and migraine symptoms
 - episodes ranging 5 minutes to 72 hours,
 - exclusion of other causes.
- **No specific test has been so far proposed for VM**

Vestibular migraine

- A. At least 5 episodes with vestibular symptoms of moderate or severe intensity, lasting 5 min to 72 hours
- B. Current or previous history of migraine with or without aura according to the International Classification of Headache Disorders (ICHD)
- C. One or more migraine features during at least 50% of the vestibular episodes:
OR 1. headache with at least two of the following characteristics: one sided location, pulsating quality, moderate or severe pain intensity, aggravation by routine physical activity
- 2. photophobia and phonophobia
- 3. visual aura
- D. Not attributable to another disorder, in particular not to another vestibular disorder

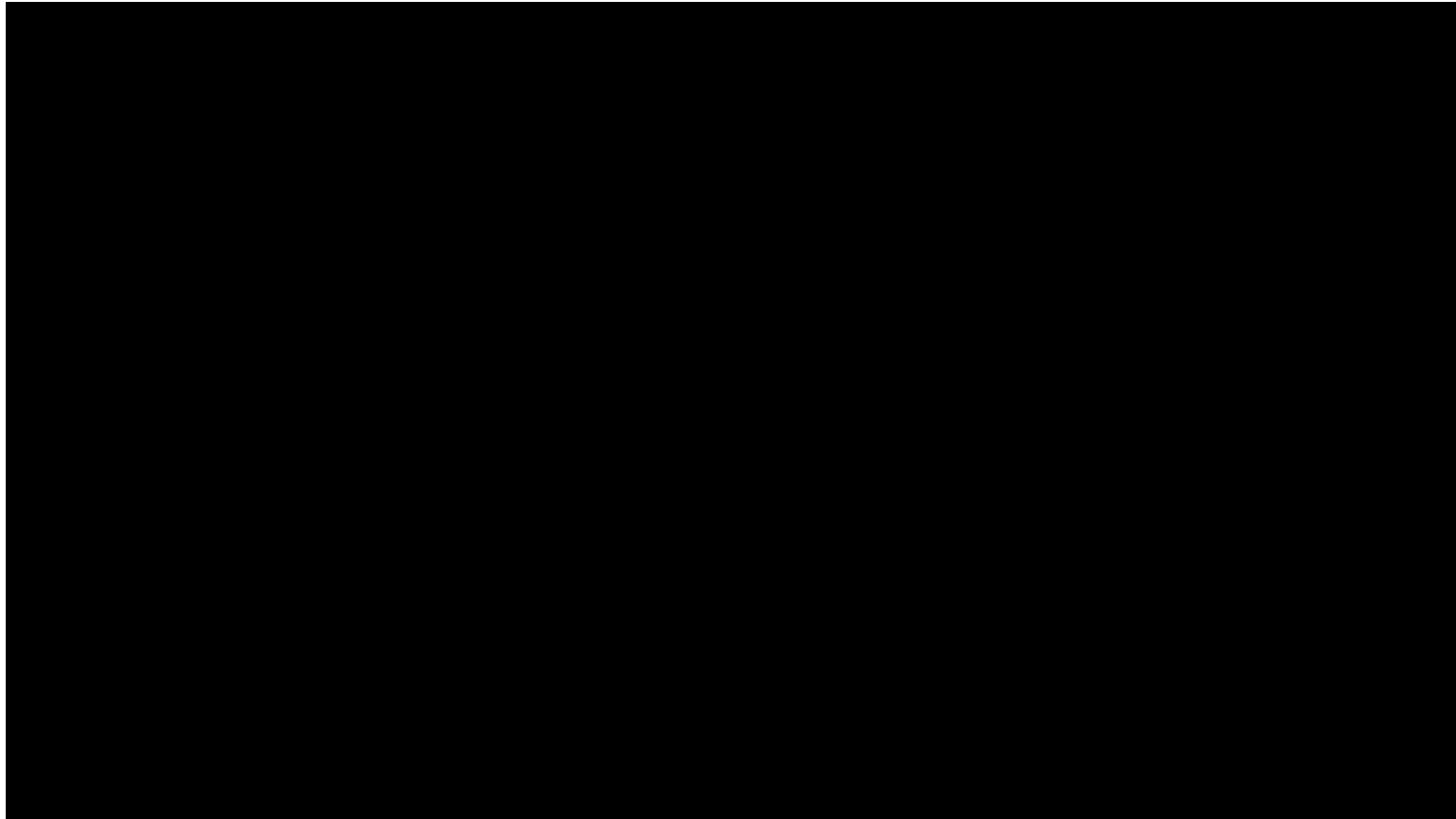
**Subjective criterion
depending on
expertise**

THE ROTATING BACKGROUND + FHIT

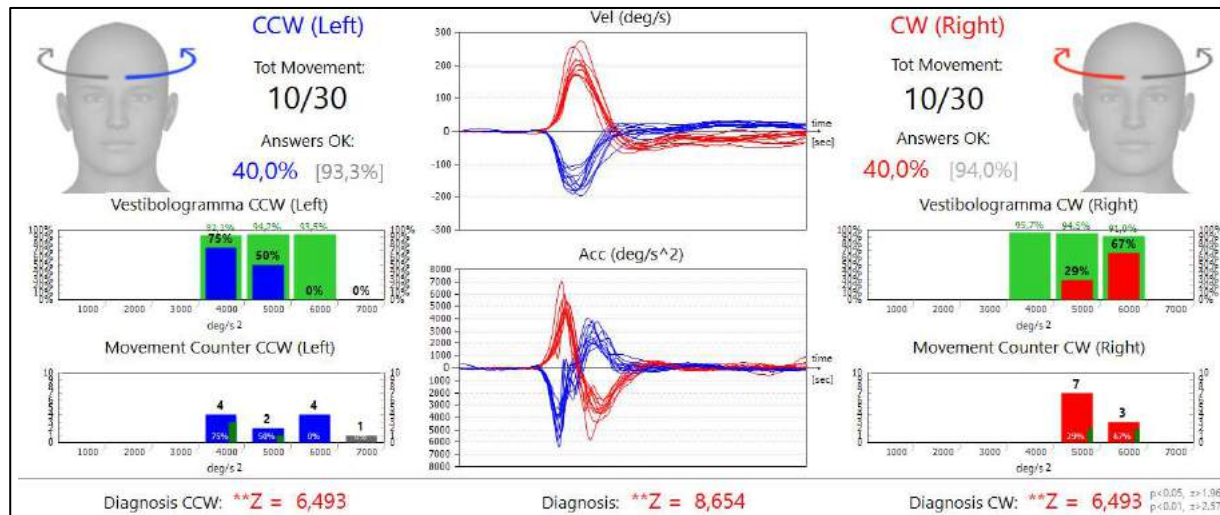
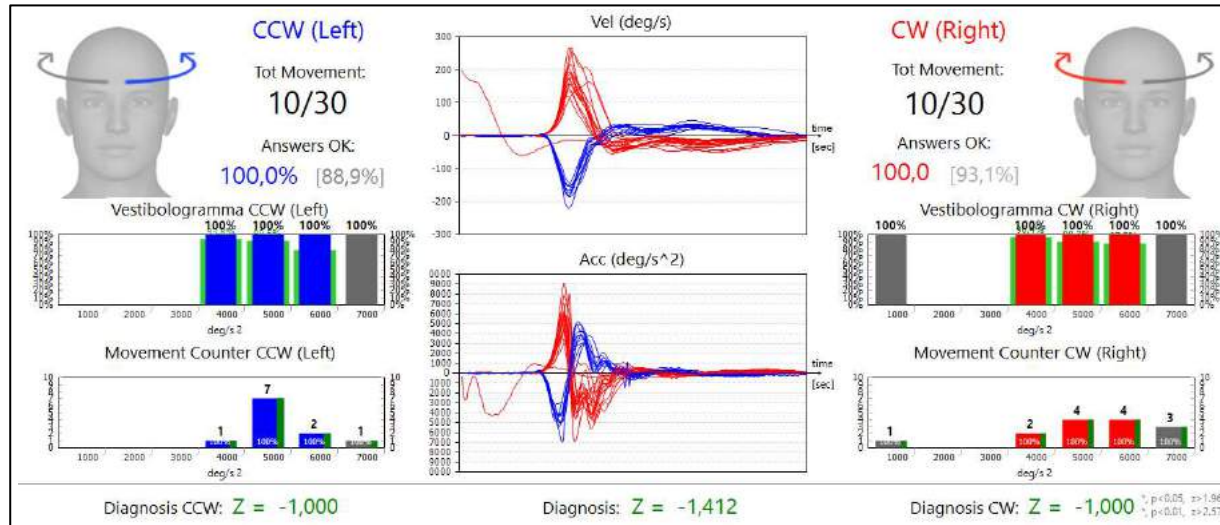
Background:

Visual Vertigo (Guerraz et al., 2001)

Postural-perceptual dizziness (Dieterich and Staab, 2016)



VISUO-VESTIBULAR “EFFECT” in VESTIBULAR MIGRAINE



With
rotating
frame on

Groups:

Controls

Migraine with/without aura (ICHD-III)

Vestibular Migraine (ICHD-III, Barany)

Intervention:

**FHIT vs FHIT-OKN (H-FVOR), DHI, Situational Vertigo
Questionnaire, Activity Balance Confidence scale,
motions sickness.**

(VHIT-OKN ancillary study)

N° subjects:

112 (Multicentric study: Siena-Pavia-Perugia)

Sex (M/F):

25/87

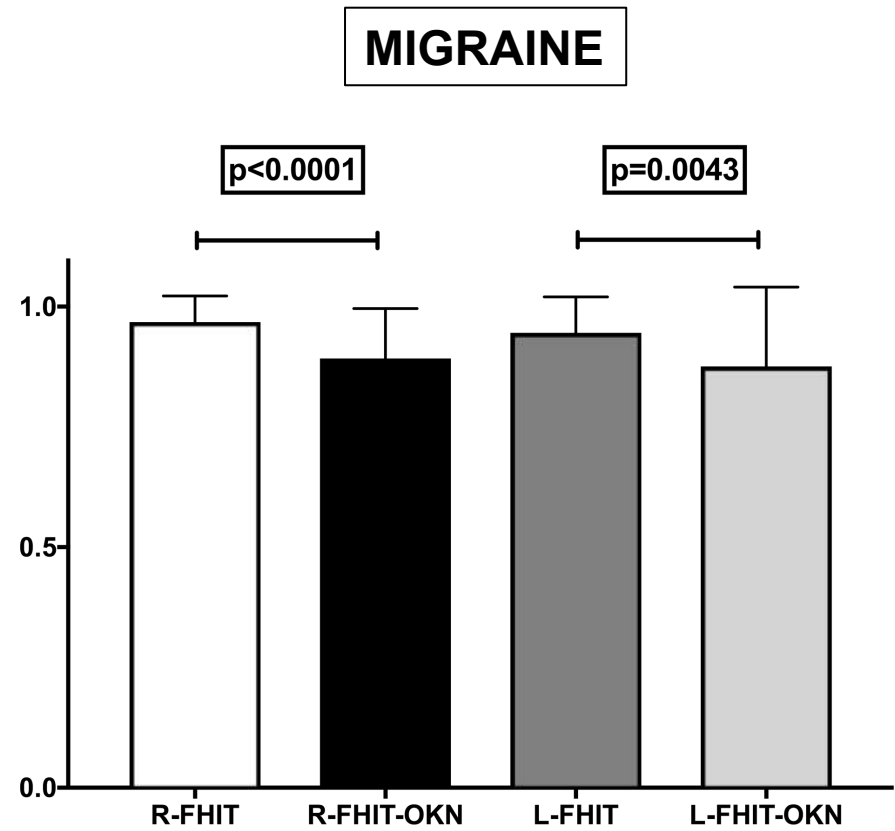
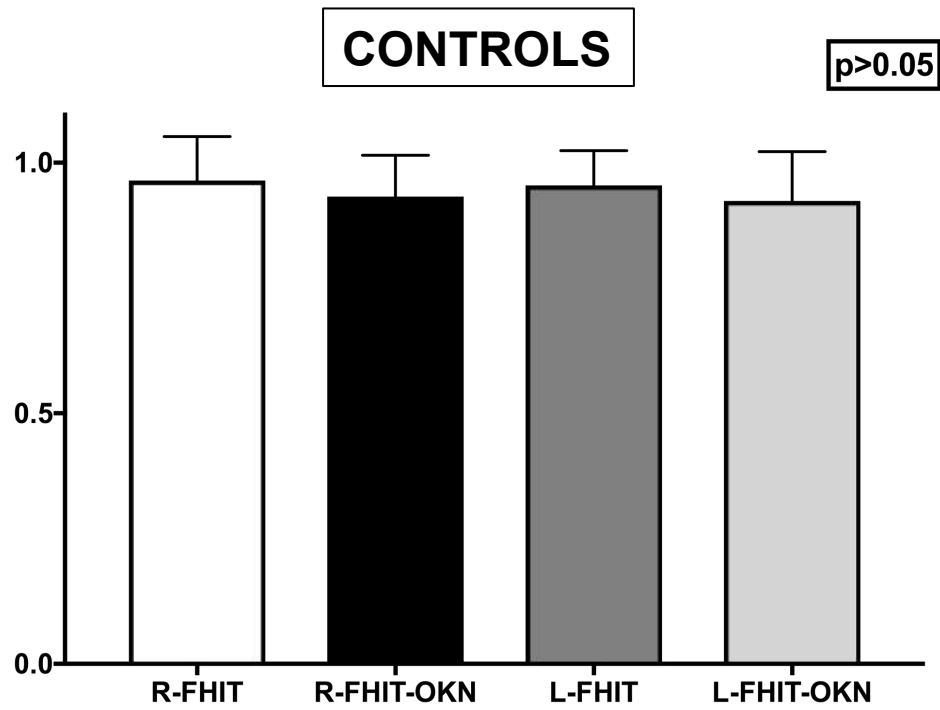
Age (years):

39.11±13.94

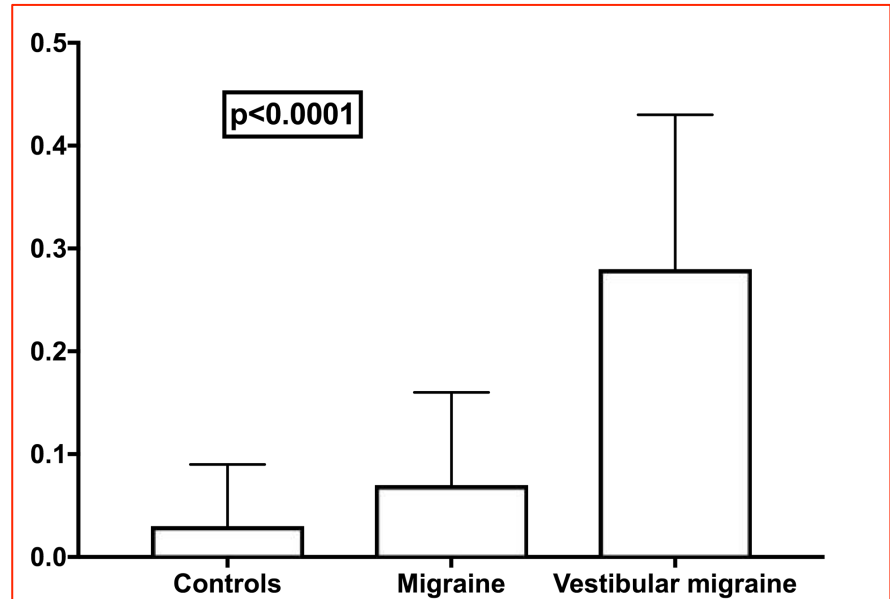
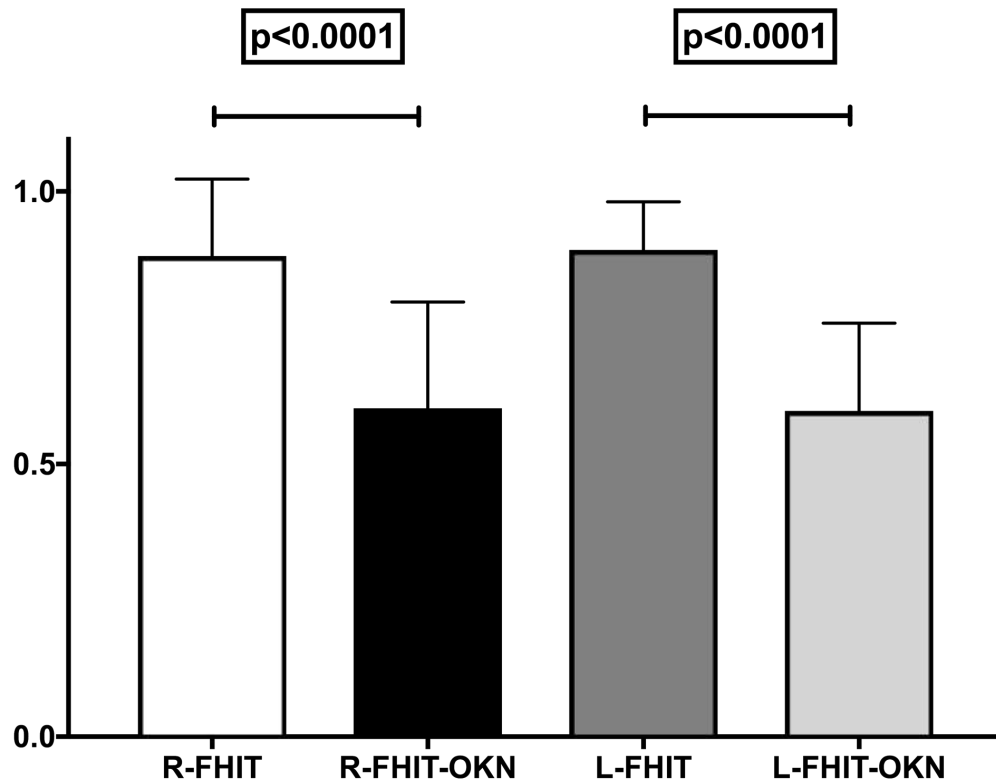
Design:

**Randomly performed FHIT or FHIT-OKN and all questionnaires
in a single session**

	CONTROLS	MIGRAINE	VESTIBULAR MIGRAINE
Number	41	36	35
Age (years)	39±15.32	33.81±12.14	44.69±12.04
Sex (M/F)	22/19	2/34	1/34
Aura (yes/no)	/	9/27	5/30
Motion sickness (yes/no)	/	13/23	14/21



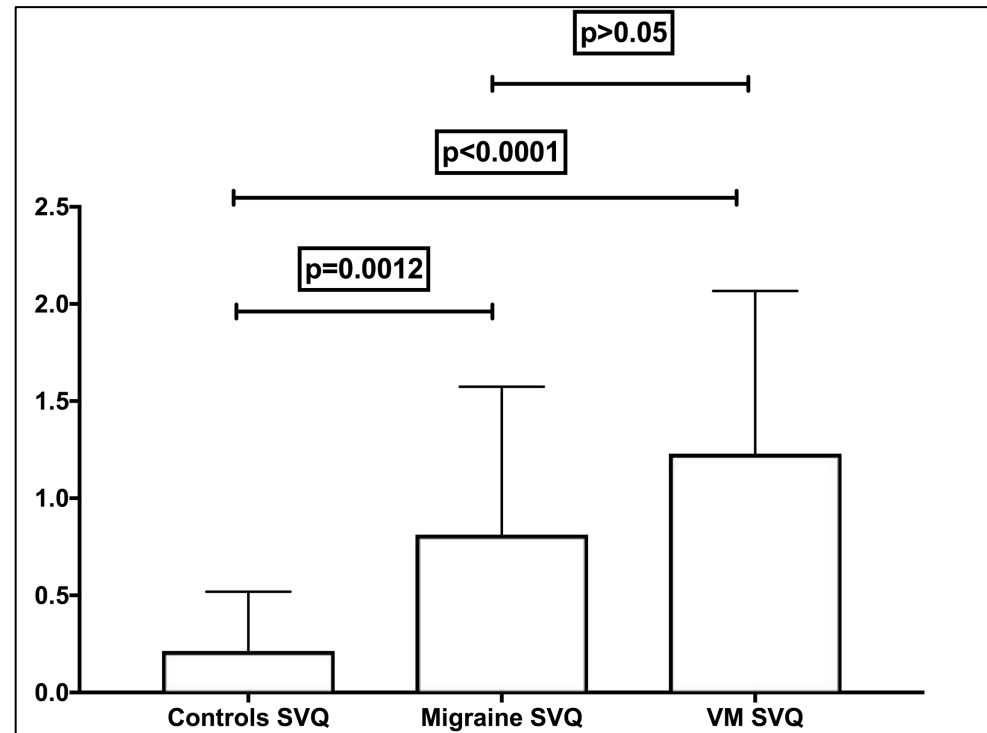
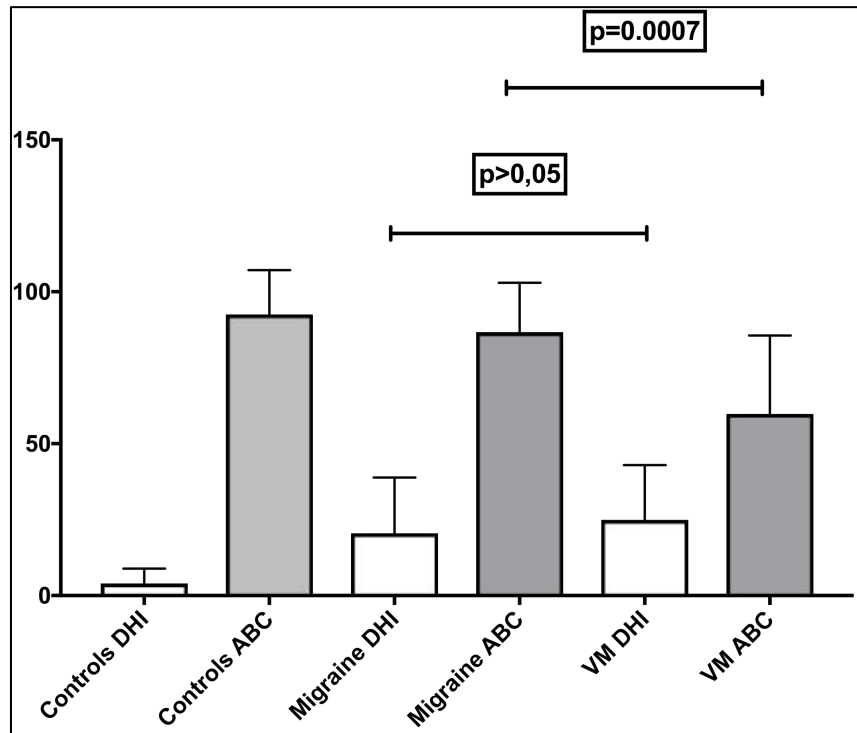
VESTIBULAR MIGRAINE



≥20% F-HIT-FHIT/OKN (at least 1 side)

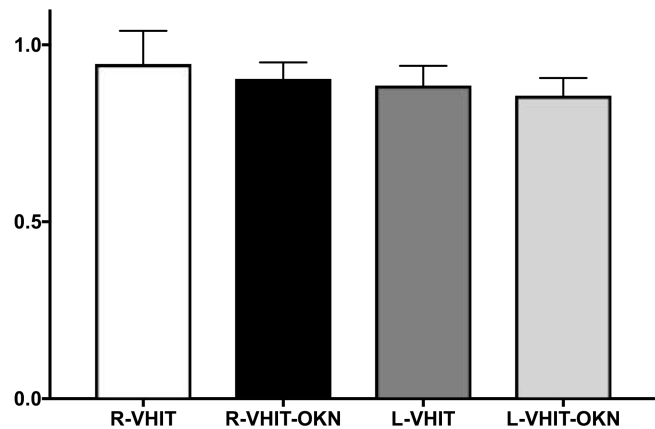
CONTROLS	MIGRAINE	VM
/	12/36 (30%)	32/35 (91%)

DHI, ABC and SVQ Questionnaires

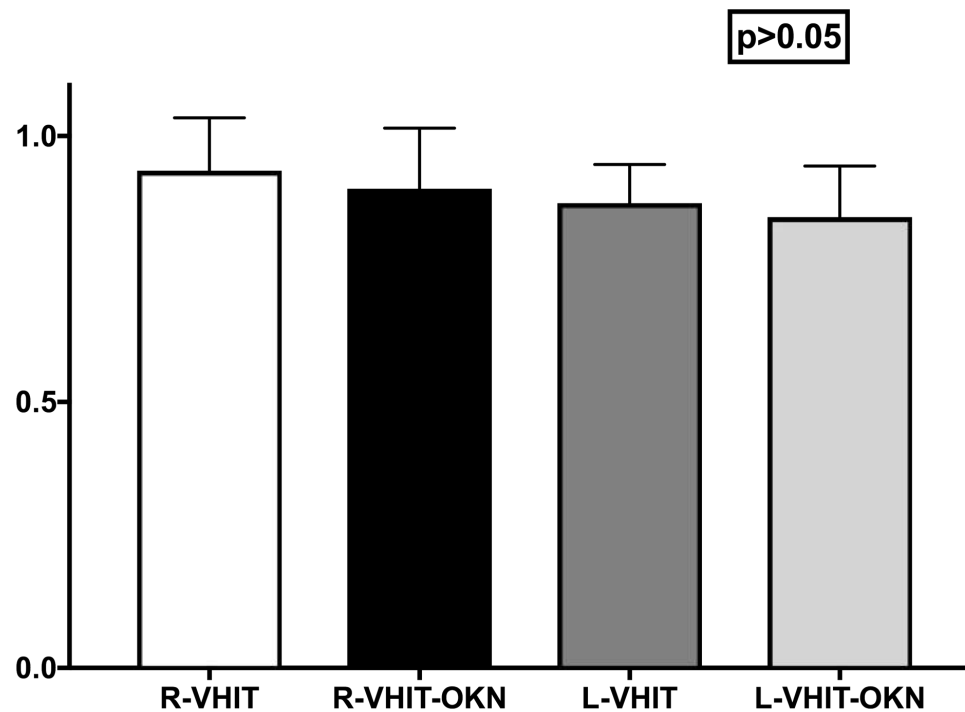


VHIT-OKN

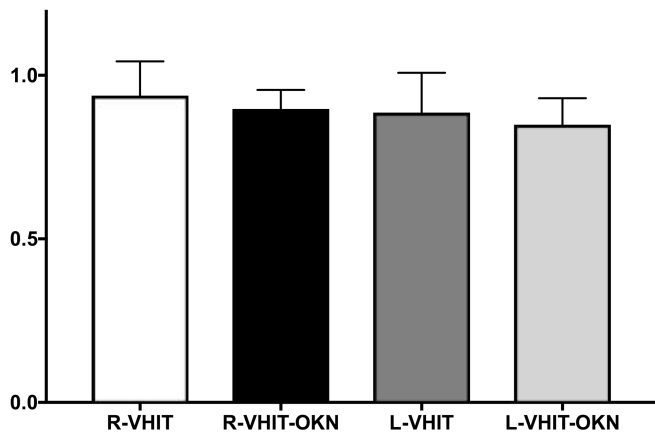
CONTROLS (8 subjects)



VESTIBULAR MIGRAINE (10 subjects)



MIGRAINE (8 subjects)



CONCLUSIONS

Most common diagnosis in neurotology clinics

Possibly overdiagnosed

Treatment side effects

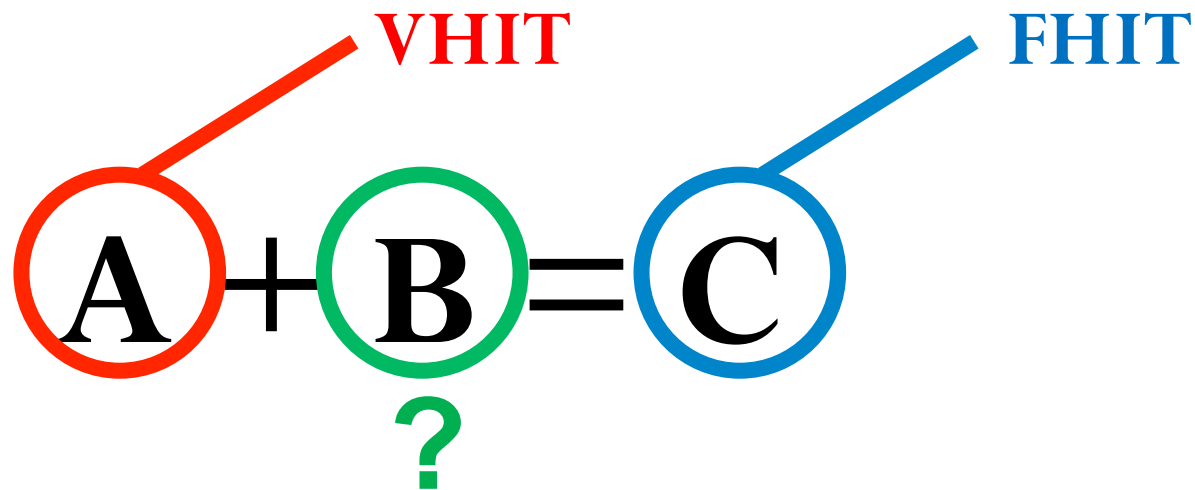
FHIT-OKN new tool for identify VM

Possibile implications for Rehab

**Possible early identification of subjects with migraine
that may develop VM**



In case you were the last audiologist on an remote island would you prefer to have with you the pure tone or speech audiometry?





THANK YOU