International Journal of Medical and Allied Health Sciences

ISSN: 2583-1879

Research Article

Analysing Vestibulo-ocular and Oculomotor Reflex with Advancing Age

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Article Information: Received on 27-06-2023 Accepted 28-07-2023 Available online 17-09-2023

Abstract

Background: Video Head Impulse Test (v-HIT) and saccades test of Videonystagmography (VNG) are used clinically to differentially diagnose patients into peripheral and central vestibular pathologies. However, age and clinic specific norms are required for both the tests.

Aims: To investigate if there is any changes in parameters of v-HIT and saccades test with advancing age.

Design: A prospective cross sectional research design study was carried out from April 2023 to June 2023 at the department of School of Audiology & Speech Language Pathology.

Method & Materials: Individuals between the age range of 20- 80 years were included in the study. Participants with no history of vertigo, neurodegenerative disorders, negative Fukuda stepping and Romberg test were included. All of them underwent through v-HIT followed by saccades test of VNG.

Results: Total 60 individuals participated in the study. Mean and SD values for gain, number of saccades and amplitude of saccades were determined as the parameters of v-HIT. On studying effect of age on vHIT, gain parameter was found to be changing with advancing age. Further, Mean and SD were also determined for velocity, precision and latency parameter of saccade test which was performed in horizontal and vertical planes at 0.3 Hz, 0.45 Hz and 0.6 Hz frequency of target stimulus. latency parameters were observed to be increasing with increase in age of participants.

Conclusion: Age specific norms are necessary especially for gain parameter of vHIT test and latency parameter of saccade test.

Key words: Video Head Impulse Test (v-HIT), Videonystagmography (VNG)

1. Introduction

In human beings, the vestibulo-ocular reflex (VOR) results in compensatory eye movements in the opposite direction of head movement in order to stabilizes the images of an object on the fovea of eyes. This occurs when an object in the visual field is stable while head is being moved in a particular direction. [1]. On the other hand, saccades or saccade reflex are rapid eye movements in order to follow the moving objects or images while head being stable.

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doi: https://doi.org/10.54618/IJMAHS.2023325

The brainstem contains various types of neurons involved in saccade generation, including long lead burst neurons (LLBNs), medium lead burst neurons (MLBNs), excitatory burst neurons (EBNs), inhibitory burst neurons (IBNs), and omnipause neurons (OPNs). These neurons are located in the midbrain, pons, and medulla, and they provide the saccadic drive to the agonist and the antagonist of eye [2].

The video head impulse test (v-HIT) is a relatively newer clinical tool to measure the angular vestibulo-ocular reflex (VOR). [3]. The v-HIT uses high-speed cameras to record eye movements and motion sensors to measure head movements. Previously investigators evaluated VOR using video head impulse test (v-HIT) in normal subjects and characterized the catch-up saccades (CSs) with ICS Impulse 3-D v-HIT system. [4,5] The mean v-HIT gain was reported to be 1.02 ± 0.07 for all SCC, and the mean gain asymmetry was found to be 2.39 ± 1.96%, with no significant differences among age groups. CSs were observed in

49% of the ears. The incidence of CSs was not associated with age.

Saccades test of VNG (video-nystagmography) is a clinical test that assesses occulo-motor reflex mediated through higher brainstem structures and cerebellum. In one of the earlier study, effect of age on saccade reflex/oculomotor reflex was assessed using an infrared video-oculography (VOG) device (EyeSeeCam) in normal individuals aging from 6-76 years [6,7]. Mean peak velocity of saccades was reported to be 213°/s, 352°/s and 455°/s for the targets moving at 5°, 15°and 30° angles horizontally. Similarly, for vertical target position mean peak velocity of saccades was found to be 208°/s, 303°/s and 391°/s. respectively. Above studies showed that gain values and corrective saccades varied across different measuring instruments of video head impulse test. Likewise parameters of oculo-motor reflex varied from one study to another due to variation in the recording equipment and parameters of the tests. Therefore, the goal of the current study was to analyse parameters related to saccade testing using The Cyclops Medtech instrument which is being used extensively across various clinics and hospital in India. Study also aimed at investigating vestibule-ocular reflex using a commonly used device called "EyeSee Cam." in a different age range of population

2. Methodology

Study included normal healthy participants to develop the age specific norms of VOR using Video Head Impulse Tests (v-HIT) and oculo-motor reflex using Saccades test of Videonystagmography (VNG). The study was approved by the Institutional Ethics Committee dated 17/08/2022. All participants were informed about the study through a participant information sheet and written consent was taken from each participant. The collected data was kept confidential.

Participants

The present study included 60 healthy participants who had no history of dizziness at least for last one year with normal findings on Romberg and Fukuda vestibular screening test. Age range of all the participants varied from 20 to 80 years. They were grouped into Group I, Group II, and Group III with each group having 20 participants. Group I included normal healthy adults with 20 - 40 years of age, Group II included normal healthy individuals with 40 - 60 years of age range and Group III included normal healthy participants between the age ranges of 60 - 80 years. Individuals with diagnosed cases of neurodegenerative disorders, clients with uncontrolled systemic disorders, individuals with ocular disorders such as eye surgery, congenital nystagmus and chronic psychiatric disorders were excluded from the study.

Procedure

Consent was obtained from all the individuals prior to their participation in the current study. Otoscopy was done followed by case history and hearing screening at 25 dBHL at 500, 1 KHz, 2 KHz and 4 KHz on pure tone audiometry. Participants with normal results on both Otoscopy and pure tone audiometry were considered for the study with the exception of Group III participants, who were included despite having a mild high frequency sensori-neural hearing loss. Post hearing screening, Video-Head Impulse Test (v-HIT) was done using EyeSeeCam v-HIT v2 (Interacoustics) instrument. For v-HIT, participants were made to seat in a chair and goggles were placed. Calibration was done by asking individuals to focus on rightward, leftward, upward and downward on the target while head being stable. After calibration, Video head impulse test was performed by turning the person's head abruptly and unpredictably in the plane of a Semi-circular canals (SCC) about 15° and instantaneous compensatory eye movement was recorded using a camera and recording software. During each head impulse, client was instructed to focus on an earth fixed target, and compensatory eye movement was observed. In this way ten short brisk jerks (velocity above 100°) were given on each side. Individuals were instructed to keep looking at the target during the given jerks. Gain values of each compensatory eye movement i.e. VOR at 60 ms was noted. In some cases, few individual's eyes may move with head during head impulse and then come back to earth fixed target making corrective saccade. Following criteria was used to mark the presence of such corrective saccade: saccade before 350 ms with amplitude greater than 50% of peak head velocity and duration between 30-50 ms. [8]

Post v-HIT, Saccade test of Video Nystagmography (VNG) was done using Cyclops Medtech Balance Eye version 3.2.4.8. For this, calibration was carried out after placing goggles on participant's eyes. Saccades test was done at 0.3 Hz, 0.45 Hz and 0.6 Hz in horizontal and vertical plane by instructing the participant to follow the target without anticipating and moving their head. Minimum 10 cycles were recorded for each frequency and plane. Analysis of Saccade test was done by measuring 'Velocity' and 'Precision' parameters of the test.

3. Results

All statistical analysis was carried out in the JASP Version 0.17.2.1. Normality testing was done using Shapiro- Wilk test of normality which revealed that the gain parameter of vHIT tests followed a normal distribution, except for values of the Left Lateral canal in Group III. However, the number of saccades, and gain asymmetry parameter did not follow a normal distribution. Whereas all the parameters of saccade test followed a normal distribution across all groups.

Parameters of v-HIT

In order to investigate vHIT findings across different age range, descriptive statistics was applied for the parameters of v-HIT. Figure 4.1 shows mean and SD values of gain parameter of 6 SCCs across the participants of three age groups.

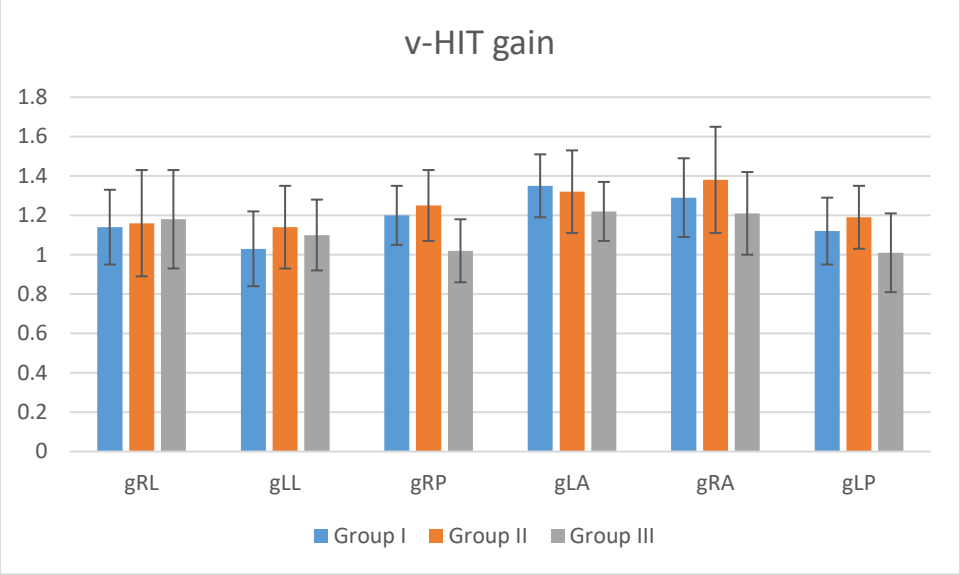

Figure 4.1: *Mean and SD value of gain parameter on vHIT test*

Note: gRL: Gain of Right Lateral, gLL: Gain of Left Lateral, gRA: Gain of Right Posterior, gLA: Gain of Left Anterior, gRA: Gain of Right Anterior, gLP: Gain of Left posterior.

	Group I		**Group II**		**Group III**	
	Median	**IQR**	**Median**	**IQR**	**Median**	**IQR**
gaLL	5.74	6.62	3.35	10.32	8.6	7.73
gaLARP	5.3	4.32	3.97	6.24	10.17	2.78
gaRALP	7.365	12.46	5.83	6.96	10.11	8.42

Table 1.1. *Descriptive statistics for gain asymmetry*
Note: gaLL: Gain asymmetry in Lateral plane, gaLARP: Gain asymmetry in LARP plane, gaRALP: Gain asymmetry in RALP plane

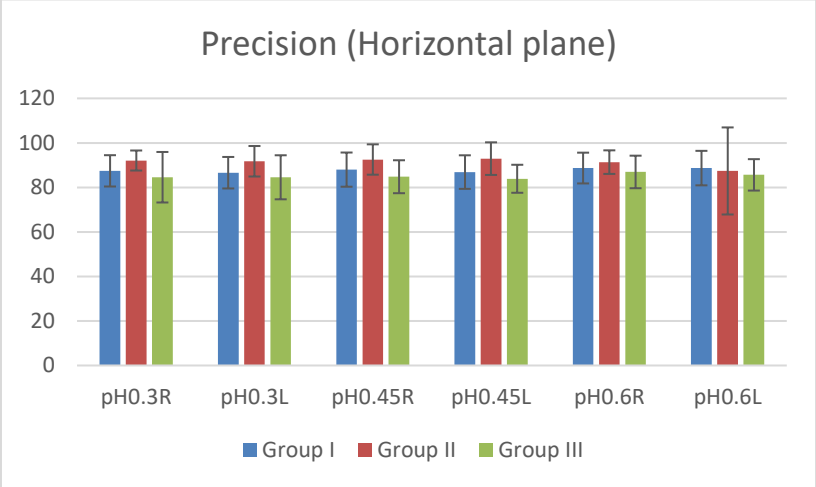

Figure 1.3. *Mean and SD values of Precision (Horizontal plane) parameter on saccade test of VNG*
Note: p: Precision, H: Horizontal, R: Right eye, L: Left eye, 0.3, 0.45. and 0.6 velocity of target stimulus using during saccade test

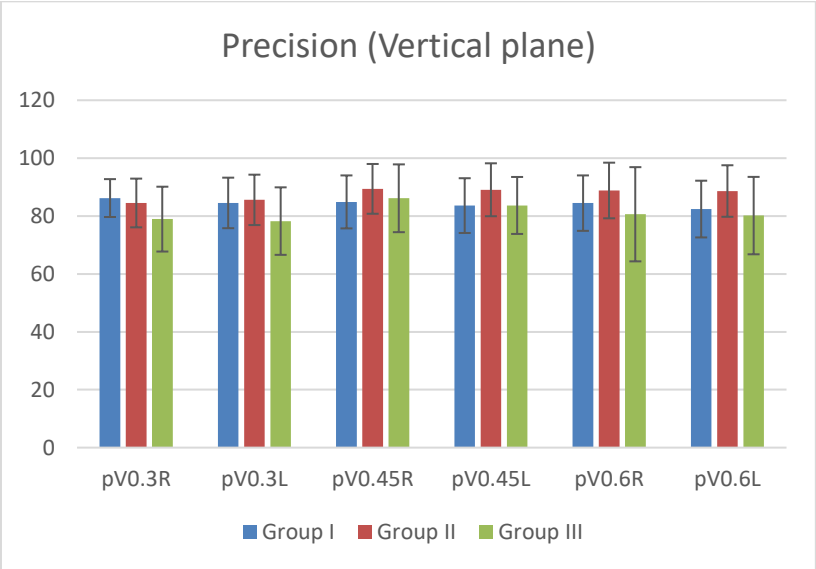

Figure .1.4. *Mean and SD values of Precision (Horizontal plane) parameter on saccade test of VNG*

Note: l: Latency, H: Horizontal, V: Vertical, R: Right eye, L: Left eye, 0.3, 0.45. and 0.6 velocity of target stimulus using during saccade test

It can be observed that in Figure 4.1. that gain values are varying from 1.01. to 1.38 across all canals as well as across all age groups. It can be seen that gain for both anterior canals are comparatively higher than others. Gain for both posterior canals can be seen reduced for group III.

To investigate the age effect on gain parameter, ANOVA test was done and revealed that there is no significant difference between mean gain values across age groups for Right Lateral canal F (2,45) =0.086, p=0.918; Left Lateral canal F (2,45) =1.468, p=0.241; Right Anterior canal F (2,45) =1.803; p=0.176 and Left Anterior canal F (2,45) =1.819, p=0.174. However, there was significant difference between mean gain values across age group for Right Posterior canal F (2,45) =7.00, p=0.002; Left Posterior canal F (2,45) =3.425, p=0.041. Tukey test was done for post hoc analysis and it revealed difference between mean was observed between Group I and III (p tukey=0.015), Group II and III (p tukey=0.002) for right posterior canals and between Group II and III (p tukey=0.032) for left posterior canal. This indicated that only posterior canal has age related changes on gain parameter of v-HIT.

As part of first objective to investigate gain asymmetry parameter of v-HIT test across different age groups, median and Interquartile range was computed using descriptive statistics. Table 4.1. shows the values for gain asymmetry values for all three planes.

It can be seen in the Table 4.1. that gain asymmetry values are increasing from younger age group to older age group, nevertheless Kruskal Wallis test showed no significant age effect in gain asymmetry.

Number of corrective Saccades was analysed as a third parameter of v-HIT using descriptive statistics as shown in Table 4.2.

It can be observed in Table 4.2. that corrective saccades were observed only in lateral plane except one or two individuals. Number of maximum corrective saccades that were observed were not more than 3 in number. Those participants who had catch up saccades only 1st saccades were observed except 2 participants of Group I and Group III who had 2nd catch up saccades.

In Figure 4.2. early response artifact in lateral canals can be observed. This artifact resulted in higher gain at 40 ms and lower gain values at 60 ms. 4.2. Parameters of Saccades test of VNG

Velocity and precision parameters of saccade test was analysed at target frequency of 0.3. 0.45 and 0.6 HZ. Figure 4.3. and Figure 4.4. shows the error bar graph of mean and SD values for velocity parameter of saccades test for all age groups in horizontal and vertical plane respectively.

It is observed that velocity of eyes was increasing as the velocity of the target (ms) was increased. But it was observed only for horizontal plane, for vertical plane change in velocity was not much observed. The mean values of velocity parameter of eye movement were lower for the target moving in vertical plane than the horizontal plane across all age groups.

Figure 4.5. and Figure 4.6. depicts the mean and SD of precision parameter of saccades test for horizontal and vertical planes respectively.

The error graph of precision shows that the error is higher (%) in the horizontal plane than in the vertical plane for all age groups. Decrease in precision was observed for Group III. Lower precision was found for group III for lower velocity of target in both the planes. The standard deviation was high for the velocity parameter and low for the precision parameter,

indicating that precision is a more reliable parameter for diagnosis.

ANOVA statistical test was applied in order to investigate if there was any change in precision parameters of saccade test with advancing age. Results revealed that there was no change in the velocity parameter of saccade test for both horizontal and vertical plane with increase in age.

4. Discussion

Present study revealed average gain values to be 1.1 for posterior and lateral canal across all the three groups of participants whereas it was 1.3 for anterior canal when assessed using v-HIT test. These gain values were comparable with former study who reported average gain values varying from 1.0 to 1.1 for all the three semi-circular canals on v-HIT test [9]. There was minimal differences in the average values of gain parameters for anterior canal between current study and previously reported literature which could be because of clinician and subject related factors such as amount of clinician's practise and head circumference of an individual. Other factors that may contribute for the differences in the gain values could be related to the Inertia of the goggles and weight of the goggles. This indicates that each clinic should have its own norms for v-HIT specific to their equipment.

Current research also showed that there was a reduction in gain values of VOR only for posterior canal with increase in age when assessed using v-HIT. This indicated that inferior vestibular nerve bundles or hairs cells of posterior SCC are more susceptible to age related changes as compared to hairs cells of other canals. Nevertheless, present findings contradict with earlier investigator reported age effect only for lateral canal of vestibular organ. [11]

For Saccades test in VNG, velocity and precision parameter were observed to be not changing significantly with increase in age. Nevertheless, mean velocity was observed to be clinically increasing and precision was found to be decreasing as the frequency of target was increased from 0.3 Hz to 0.6 Hz. Results of the present study are first of its kind as no previous study has analysed parameters of saccade test using Cyclops Med Tech, across different age groups. Hence it can be concluded that saccade test of VNG can be used reliably for clinical assessment and norms should be developed for different velocities of target with clinic specific equipment

5. **Conflict of interest:** Author declares that there is no conflict of interest.

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