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Clinical practice of horizontal video head impulse test in healthy children

Sağlıklı çocuklarda horizontal video baş savurma testinin klinik uygulaması

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ABSTRACT

Objectives: This study aims to evaluate the clinical practicability of horizontal video head impulse test in healthy children and to establish normal data.

Patients and Methods: A total of 119 children (60 males, 59 females; mean age 10.64±2.8 years; range 6 to 16 years) participated in the study, which was conducted between January 2016 and April 2016. Horizontal vestibuloocular reflex (VOR) was measured with a portable video-oculography device in a seated position in room light. VOR gain was calculated at 40, 60, and 80 milisecond. Refixation saccades were analyzed and participants' reasons for test failure were recorded.

Results: Sufficient and reproducible measurements were acquired for 51 male and 49 female participants (mean age 10.64±2.77 years) (100/119 children, 84%). There was no significant difference between right and left ears in terms of median gain values. There was a statistically significant difference between median gain values at 40, 60 and 80 milisecond for right and left ears ($p<0.05$). There was no significant difference between male and female participants in terms of median gain values.

Conclusion: Horizontal video head impulse test is a practical and tolerable diagnostic tool for evaluating lateral canal functions in children aged between 6 to 16 years.

Keywords: Children; reflex; vestibuloocular; video head impulse test.

ÖZ

Amaç: Bu çalışmada sağlıklı çocuklarda horizontal video baş savurma testinin klinik uygulanabilirliği değerlendirildi ve normal değerler ortaya kondu.

Hastalar ve Yöntemler: Ocak 2016 - Nisan 2016 tarihleri arasında yapılan çalışmaya 119 çocuk (60 erkek, 59 kız; ort. yaş 10.64±2.8 yıl; dağılım 6-16 yıl) dahil edildi. Horizontal vestibülooküler refleks (VOR) oda ışığında, oturur pozisyonda, taşınabilir video-okülografi cihazı ile ölçüldü. VOR kazancı 40, 60 ve 80 milisaniyede hesaplandı. Refiksasyon sakkadları analiz edildi ve katılımcıların testte başarısızlık nedenleri kaydedildi.

Bulgular: Yeterli ve tekrarlanabilir ölçümler 51 erkek ve 49 kız katılımcıda (yaş ort. 10.64±2.77 yıl) elde edildi (100/119 çocuk, %84). Ortanca kazanç değerleri açısından sağ ve sol kulaklar arasında anlamlı farklılık yoktu. Sağ ve sol kulakta 40, 60 ve 80 milisaniyedeki ortanca kazanç değerleri arasında istatistiksel olarak anlamlı farklılık vardı ($p<0.05$). Ortanca kazanç değerleri açısından erkek ve kız katılımcılar arasında anlamlı farklılık yoktu.

Sonuç: Horizontal video baş savurma testi 6-16 yaş arası çocuklarda lateral kanal fonksiyonlarını değerlendirmede kullanışlı ve tolere edilebilir bir tanı aracıdır.

Anahtar Sözcükler: Çocuklar; refleks; vestibülooküler; video baş savurma testi.

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The video head impulse test (vHIT) is a recently developed diagnostic tool that records eye and head velocity response to brief, unpredictable and passive head rotations, which is called a head impulse.[1] The adjunct video system provides a technological advancement to the classical clinical head impulse test, which measures vestibulo-ocular reflex (VOR) deficits due to peripheral vestibular disorders by simple observation.[2] In adults, vHIT has been shown to be an effective tool for diagnosing semicircular canal disorders.[3-5]

The prevalence of vestibular disorders ranges between 0.7% and 15% in children.[6-8] During childhood, establishing an accurate diagnosis of vestibular dysfunction is usually a challenging task due to the failure of adequate communication and intolerability of vestibular tests such as rotatory chair testing or caloric test. However, vHIT is a relatively easy, objective and more rapid vestibular test that may be less anxiety-provoking in children than classical vestibular tests examining semicircular canal deficits.[9] In the present study, we aimed to evaluate the clinical practicability of horizontal vHIT in healthy children and establish normative data for the vHIT in Kayseri Training and Research Hospital, Kayseri, Turkey.

PATIENTS AND METHODS

Written informed consent was obtained from the parents of the children and the study protocol was approved by the Ethics Committee of the Erciyes University School of Medicine (Reference: 2015/484). The study was conducted in accordance with the principles of the Declaration of Helsinki. The present study was conducted in the Department of Otorhinolaryngology Head and Neck Surgery of the Kayseri Training and Research Hospital between January 2016 and April 2016. A detailed medical history was obtained from participants and their parents and medical records were meticulously reviewed for any diagnoses. All children had normal vision and underwent comprehensive otologic and neurologic examination by an experienced otolaryngologist. After these evaluations, a total of 119 children (60 males, 59 females; mean age 10.64±2.8 years; range 6 to 16 years) who were free of any otologic, vestibular and/or ocular diseases participated in the present study. Horizontal VOR was measured in the horizontal plane in seated position and room light by a licensed audiologist and a trained assistant using a portable video-oculography system (EyeSeeCam©, Interacoustics, Eden Prairie, MN). During testing, children wore a pair of lightweight goggles integrated with a gaze-driven high-speed digital camera system (sampling rate of 220 Hz) that recorded real time eye movement, a motion sensor that measured head movement, and a laser light for calibration. Initially, the calibration process was performed to obtain reliable recordings by means of integrated laser dots projected on a wall. After calibration, the child was instructed to fixate on a target located on the wall approximately one meter straight ahead. At least 10 unpredictable head impulses in the horizontal plane (head rotation 5-15°, duration 150-200 milisecond (ms), target head velocity 100-200°/second) were administered for each site. The tests were performed in a single session and subjects who provided sufficient and reproducible test measurements were included in the study. Vestibulo-ocular reflex gain was calculated as the ratio of eye to head velocity at 40, 60 and 80 ms. Refixation saccades were also analyzed and classified as a covert saccade when it occurred during the head movement and as an overt saccade when it occurred after the head movement. The reasons for test failure were also noted in the study group. Vestibulo-ocular reflex gain values at 40, 60 and 80 ms were compared between right and left ears, and between male and female subjects. The study group was also classified into three age groups according to a former description of Ross and Helminski[10] based on maturation of the cervical spine. The age groups were less than eight years of age, 8 to 12 years of age, and greater than 12 years of age, and vHIT values were compared among the groups.

Statistical analysis

The data were analyzed with IBM SPSS version 21.0 software (IBM Corp., Armonk, NY, USA). Data were expressed as mean ± standard deviation. Descriptive statistics were used to measure time spent for vHIT, VOR gain and gain variance. Kruskal-Wallis and Mann-Whitney U tests were performed to compare the differences in gain between

40, 60 and 80 ms. A *p* value less than 0.05 was considered significant for all comparisons.

RESULTS

A total of 19 children could not accomplish the test for different reasons including a lack of interest in 12, agitation and fear that hindered test compliance in five and failure of calibration in two children. Sufficient and reproducible measurements were acquired for 51 male and 49 female subjects (100/119 children, 84%) with a mean age of 10.6±2.8 years (male=10.7±2.7 years, female=10.6±2.9 years). The mean time required for performing vHIT was approximately 30 minutes. The mean number of impulses was 12.1±2.1 for the right ears and 12.3±2.34 for the left ears. The mean number of impulses was not statistically different between right and left ears. A laser calibration system was found to be practical in children older than six years old and the median gain of right and left ears was 0.95±0.11 and 0.92±0.12, respectively. There was no significant difference between right and left ears in terms of median gain (p=0.065). The median gain values for 40, 60 and 80 ms for right and left ears are shown in Table 1. There was no significant difference between right and left ears concerning median gain after 40, 60 and 80 ms. There was a statistically significant difference in terms of median gain value for 40, 60 and 80 ms for both right and left ears. With regard to gender, mean values of vHIT in the right and left ears are shown in Table 2 and Table 3, and there was no significant difference between male and female subjects in terms of median gain values. According to age groups, there was a significant difference among groups in values of median gain after 60 and 80 ms in both ears. Other values of vHIT testing were similar between age groups (Table 4, Table 5). None of the subjects demonstrated overt or covert saccades in vHIT testing.

Table 1. Median gain values in right and left ears

	Right ear (n=50)	Left ear (n=50)	
	Mean±SD	Mean±SD	*p*
40 ms	1.1±0.3	1.1±0.2	0.322
60 ms	0.9±0.1	0.9±0.1	0.108
80 ms	0.8±0.1	0.8±0.1	0.552
p	<0.001	<0.001	

SD: Standard deviation; ms: Millisecond; vHIT: Video head impulse test.

DISCUSSION

During vestibular system evaluation, application of conventional vestibular tests such as caloric and rotary chair testing may have some limitations in children. Caloric testing may be difficult to perform in children because of its adverse effects, such as vertigo and nausea.[11] The rotary chair can also be intolerable due to its nature concerning spinning in a small, dark and closed area.[12] On the contrary, vHIT has some advantages that can make it easy to perform in children. These advantages are the applicability of the test in an open and lighted room without provoking dizziness and being less frightening for children. Hülse et al.[13] demonstrated reproducible test results in 76% of a study population consisting of 55 children during horizontal vHIT testing. In their study, the reasons for failure were mainly due to incompliance to the test (n=7), voluntary or involuntary contraction of the cervical muscles that hinder head rotation (n=7), failure of calibration (n=3) and problems with keeping eyes open (n=3). In the present study, reproducible and sufficient test results were acquired in 84% of the

Table 2. Values of video head impulse test parameters in the right ears of male and female subjects

	Male (n=50)	Female (n=50)	
	Mean±SD	Mean±SD	*p*
Median gain	0.9±0.1	1.0±0.1	0.639
40 ms	1.1±0.2	1.1±0.3	0.625
60 ms	0.9±0.1	0.9±0.1	0.873
80 ms	0.8±0.1	0.8±0.1	0.473

SD: Standard deviation; ms: Millisecond.

Table 3. Values of video head impulse test parameters in the left ears of male and female subjects

	Male (n=50)	Female (n=50)	
	Mean±SD	Mean±SD	*p*
Median gain	0.9±0.1	0.9±0.1	0.117
40 ms	1.0±0.2	1.1±0.2	0.081
60 ms	0.9±0.1	0.9±0.2	0.168
80 ms	0.8±0.1	0.8±0.1	0.469

SD: Standard deviation; ms: Millisecond.

Table 4. Values of video head impulse test parameters in the right ears according to age groups

	<8 years (n=26)	8-12 years (n=52)	>12 years (n=22)	
	Mean±SD	Mean±SD	Mean±SD	*p*
Median gain	0.9±0.1	0.9±0.1	1.0±0.1	0.142
40 ms	1.0±0.2	1.1±0.3	1.1±0.2	0.419
60 ms	0.8±0.1	0.9±0.1	0.9±0.1	0.001
80 ms	0.7±0.1	0.8±0.1	0.8±0.1	0.001

SD: Standard deviation; ms: Millisecond; vHIT: Video head impulse test.

Table 5. Values of video head impulse test parameters in the left ears according to age groups

	<8 years (n=26)	8-12 years (n=52)	>12 years (n=22)	
	Mean±SD	Mean±SD	Mean±SD	*p*
Median gain	0.9±0.1	0.9±0.1	1.0±0.1	0.076
40 ms	1.0±0.2	1.1±0.2	1.1±0.1	0.281
60 ms	0.8±0.1	0.9±0.2	1.0±0.1	0.002
80 ms	0.7±0.1	0.8±0.1	0.8±0.1	0.015

SD: Standard deviation; ms: Millisecond; vHIT: Video head impulse test.

study population. The major problems during vHIT application were a lack of interest in 12, agitation and fear that hindered test compliance in five and failure of calibration in two children. The better rate of acquiring sufficient test results in the present study can be explained by the age range of the study population (6-16 years), which was relatively higher than the study of Hülse et al.[13] (3-16 years).

The video head impulse test has some technical advantages concerning vestibular evaluation when compared with the clinical head impulse test, rotary chair and caloric testing. Covert saccades, which are difficult to identify with the naked eye, are much better detected with vHIT than with the clinical head impulse test.[14] The video head impulse test also provides a quantitative measurement of vestibular dysfunction in each canal that provides objective verification of individual semicircular canal dysfunction and response to treatment modalities.[10] Higher frequencies of head rotation of 4-5 Hz can be evaluated with the vHIT test, which may allow better capture of natural head movements in active children than caloric testing (~0.004 Hz) and rotary chair (0.01-0.64 Hz).[15] On the other hand, the vHIT procedure can be difficult to perform in children for various reasons. First of all, vHIT obligates the subjects to fixate on a nearby target, which can be challenging in the child population. Secondly, the goggles for vHIT have to be fit as much as possible to reduce slippage in order to prevent artifacts. In the literature, it is reported that current goggles allow performing the test as young as three years old[2,9] with sufficient results. In the present study, our lower age limit was six years old because we intended to design a pilot study to explore the practicability of vHIT in children and also to provide normative data for the lateral semicircular canal as an initial goal. In addition, the high compliance rate (84%) for vHIT and nonexistence of goggle fitting problems in the present study may be attributed to the presence of a higher lower age limit than the other studies focusing on vHIT in children.[2,9]

In the present study, the mean values of gain were significantly different after 40, 60 and 80 ms and the values were significantly decreased from 40 to 80 ms. Similar significant differences were also demonstrated in the study of Hülse et al.[13] consisting of 55 children. In addition, the mean values of gain were found to be similar after 40, 60 and 80 ms among male and female subjects in the present study, and

according to these results, in children older than six years old gender may not significantly influence vHIT results. On the other hand, we also evaluated the vHIT values according to age groups. In the pediatric population, lack of inherent stiffness in the cervical spine may affect the ability to obtain higher frequency head impulses. The degree of flexibility in children will become similar to adults with maturation, as the fulcrum of movement of the cervical spine descends from C1-3 at less than eight years of age to C5-6 by adolescence.[16,17] In the present study, all the mean gains were found to be increased in the older age groups with a statistically significant difference for mean values of gain after 60 ms and 80 ms. However, these values were found to be similar among the age groups in two different studies[9,10] conducted with relatively small sample sizes. The number of participants may be the underlying factor of difference related to mean gain values between our study and the others.

The major limitation of our study was the absence of a pediatric population younger than six years old. As previously mentioned, this pilot study intended to evaluate the practicability of vHIT and also acquire normative data for the lateral semicircular canal in children older than six years old in our clinic. Also, the unequal number of participants within the age groups constitutes another weakness of the present study. Further studies that aim to demonstrate the normative data of vHIT for anterior, posterior and lateral semicircular canals involving the entire childhood period may provide better assistance during vestibular system evaluation of children.

In conclusion, in children aged 6-16 years, horizontal vHIT is a practical and tolerable diagnostic tool for evaluating lateral canal function. Further studies providing normative data will allow the use of vHIT as a screening tool to assess vestibular system impairments and objectively evaluate the treatment response in a pediatric population.

Declaration of conflicting interests

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