

ORIGINAL ARTICLE

CONTENTS

Sensitivity and reactivity of the vestibular analyzer in children

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ABSTRACT

Aim: To study the sensitivity and reactivity of the vestibular analyzer in healthy children aged 3 to 14 years. To identify the characteristics of examining children aged 3 to 14 years.

Materials and Methods: Nystagmic thresholds of children between three and seven years were found to be in the area of 8 to 24 radians per second. With age, this amplitude increased to 3 to 30 radians per second, and therefore it was possible to select, for clinical purposes, an optimal angular velocity of 30 radians per second. The reactivity of the vestibular analyzer increased with age, and also, in children over seven, with the increasing speed of rotation.

Results: Children below five were shown to have the least sensitive and reactive vestibular analyzer, while those over seven demonstrated the highest sensitivity and reactivity, which could be related to the development of the vestibular analyzer and the central nervous system.

Conclusions: Nystagmus thresholds in children under 7 years of age are within the range of 8–24 rad/s, with thresholds increasing from 3 to 30 rad/s with age, allowing a minimum angular velocity of 30 rad/s to be adopted for clinical examination. The sensitivity and reactivity of the vestibular analyzer increase with age. The lowest sensitivity and reactivity of the vestibular analyzer are observed in children younger than 5 years old, and the highest in children older than 7 years old, which coincides with the development of the vestibular analyzer and the central nervous system.

KEYWORDS: nystagmus, vestibular analyzer, sensitivity and reactivity, children of 3 to 14 years

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INTRODUCTION

It is known that the balance organ, which is formed by the time a child is born, differs significantly from its function in adults. The area of vestibular assessment in children has become popular in audiology and otorhinolaryngology clinics in recent years. If there is a slightest suspicion of vestibular involvement, due to any suspicious symptomatology, the child should be referred for appropriate neurotological evaluation, in an attempt to establish a correct diagnosis and then initiate a more appropriate treatment, if necessary [1-3]. The information available in modern literature on the state of the vestibular analyzer in children is fragmentary, incomplete, and often contradictory. The results obtained are almost always compared with those in adults, although such a comparison is not adequate, so there is a real need to study the sensitivity and reactivity of the vestibular analyzer in children, which is especially important for the further development of rational therapy for various pathological conditions.

AIM

To study the sensitivity and reactivity of the vestibular analyzer in healthy children aged 3 to 14 years. To identify the characteristics of examining children aged 3 to 14 years.

MATERIALS AND METHODS

We studied the sensitivity and reactivity of the vestibular analyzer in healthy children aged 3 to 14 years. In the course of our work, we found that examining children has a number of peculiarities. For example, it is not always possible to obtain a detailed vestibular history, even with the help of parents, so when examining children, it is necessary to focus on objective data. We often encounter a child's lack of understanding and unwillingness to comply with the conditions of the examination, as well as fatigue, so the examination must be conducted in the form of a game, without overloading the child with a large number of techniques.

The vestibular analyzer in children was examined in the vestibulometric laboratory using an electronic automatic device of our own design with dosed angular acceleration. The angular velocity was arbitrarily set from 0 to 100 radians per second (rad/s) with an accuracy of 0.1 rad/s. First, a vestibulometric examination chart was filled out, paying attention to special medical history, vestibular disorders, treatment, past illnesses that could affect vestibular function, concomitant diseases, and the condition of the ENT organs. Then we proceeded to vestibulometry. We examined statokinetic function, using the Fucuda 'writing' test from the age of 5, studying walking in a straight line with eyes open and closed, and flank walking to the right and left.

Spontaneous and positional nystagmus [3-4] were examined in terms of direction and duration while sitting with eyes closed, with the head tilted to the right and left shoulders, forward, backward, lying on the back, right and left sides, and in the Rose position. Electronystagmographic (ENG) recording of spontaneous and positional nystagmus and a rotational test were performed. The sensitivity threshold of the vestibular analyzer was determined for each patient beforehand. The sensitivity threshold was taken as the lowest angular velocity at which at least 3 nystagmus jerks appeared after the stop stimulus. Since the upper limit of the sensitivity threshold is approximately 30 rad/s [5], and the angular velocities are 70 and 90 rad/s, which are often used in clinics to study the functional state of the organ of balance, we settled on these operating modes in order to establish the sensitivity standards of the vestibular analyzer in children. The results obtained will allow us to compare them with data recorded for various pathological conditions in subsequent work. Setting and extinguishing the speed on the installation took 0.3 s, and the time of uniform rotation was 20-50 seconds, i.e., at each speed, 20 rotations to the right and left were performed, and further recording of post-rotational nystagmus was recorded by a four-channel electroencephalograph. When interpreting the ENG data, attention was paid to the duration of the nystagmus response, direction, amplitude, frequency, and slow phase velocity (SPV). Preliminary calibration of the oscillations was performed at a signal voltage of 100 m and calibration of head movements at an angle of 20 radians, with the gain set so that the nystagmus amplitude was 10 mm.

AI STATEMENT

The author states that no AI tools were used in writing this article.

ETHICS

This work complies with the principles of the Declaration of Helsinki.

RESULTS

We studied 120 healthy children in four age groups: 3-5, 5-7, 7-10, and 10-14 years old. Each group was examined three times at three speed settings. It was found that the thresholds for post-rotational nystagmus were within the range of 8-24 rad/s, which is consistent with the data of Vadzyuk et al., 2023 [11] and can be considered the norm for children under 7 years of age. In the younger (3-5 years) and middle (5-7 years) age groups, the threshold decreased to 3 rad/s, which indicates an increase in the sensitivity of the vestibular analyzer in children, which was actually close to that in adults (3-30 rad/s). Spontaneous and positional nystagmus is not detected in children with normal analyzer function. When examining children aged 3–5 years, we did not find significant differences in the parameters of post-rotational nystagmus when changing the angular velocity ($P = 0.5$; see table). Given that the sensitivity of the vestibular analyzer does not change with a change in angular velocity, we can assume a direct relationship between the former and the anatomical and physiological imperfections of both the analyzer and the child's central nervous system.

In the group of children aged 5-7 years, at angular velocities of 30 and 70 rad/s, no significant differences in the studied indicators were recorded (Table 1). At an angular velocity of 90 rad/s, the ENG parameters increased (Table 1), which is probably due to the increased sensitivity of the vestibular analyzer at this age. The same data were obtained in a study of children aged 7-10 years (Table 1). Thus, with an increase in the age of the subjects and the load on the vestibular analyzer, its sensitivity increases.

In children aged 10-14 years, with an increase in angular velocity of rotation, there is also an increase in ENG parameters (Table 1). The data obtained are similar to the previous ones.

Thus, when studying children at low angular velocities (30 rad/s), a decrease in the reactivity of the vestibular analyzer (see table) is observed with increasing age, which is probably due to the inhibitory influence of the central nervous system on the analyzer. With an increase in angular velocity (70 and 90 rad/s), the reactivity of the vestibular analyzer increases. When comparing the data obtained, it can be noted that with an increase in the load on the vestibular analyzer at the age of up to 5 years, its sensitivity does not change. At the age of 5-7 years, there is even a slight decrease in all ENG parameters, and after the age of 7, an increase in the sensitivity of the vestibular analyzer is again noted. The reactivity of the vestibular analyzer also increases (with suprathreshold stimuli) with age.

Table 1. ENG parameters in children during rotational stimulation

Age, years	Rotation to the right					Rotation to the left				
	Reaction duration, s (sec)	Fre-quen-cy, Hz	SMF rad/s	m ±	P	Dura-tion, s (sec)	Fre-quen-cy, Hz	SPV rad/s	m ±	P±
Rotation speed 30 radians per second										
3-5	27.2	1.2	12.2	0.5	0.05	28.5	1.2	12.2	0.5	0.05
5-7	22.0	1.15	13.5	0.1	0.05	21.5	1.3	13.5	0.1	0.05
7-10	28.2	0.6	12.9	0.05	0.01	27.9	0.8	13.1	0.05	0.01
10-14	20.6	1.1	9.9	0.1	0.01	24.2	1.1	10.5	0.3	0.01
Rotation speed 70 radians per second										
3-5	27.2	1.2	11.9	0.5	0.001	28.5	1.2	12.2	0.5	0.01
5-7	22.0	1.2	13.5	0.1	0.001	21.5	1.3	13.5	0.1	0.01
7-10	32.0	1.2	15.3	0.15	0.01	30.0	1.2	15.9	0.15	0.01
10-14	31.8	1.4	16.1	0.2	0.02	31.2	1.5	15.8	0.1	0.02
Rotation speed 90 radians per second										
3-5	27.2	1.0	11.2	0.5	0.5	28.0	1.1	12.7	0.5	0.5
5-7	39.2	1.6	28.5	0.15	0.01	41.1	1.7	28.9	0.17	0.01
7-10	32.5	1.3	16.4	0.2	0.001	33.5	1.3	17.2	0.3	0.001
10-14	31.6	1.6	20.6	0.1	0.001	31.2	1.5	23.3	0.1	0.001

Source: compiled by the authors of this study

DISCUSSION

This study successfully achieved its scientific goal of establishing the parameters of experimental rotatory nystagmus and compiling a graph of normal values for this nystagmus. The data obtained by the study confirm the experimental results determined in the study of the prevalence of vestibular and balance disorders in children and adolescents by renowned researchers Jong Dae Lee, Chang-Hee Kim, Seok Min Hong, Sung Huhn Kim, Myung-Whan Suh, Min-Beom Kim, Dae Bo Shim, Hosuk Chu, No Hee Lee, Minbum Kim, Sung Kwang Hong, and Jae-Hyun Seo [6].

In a study of vestibular function in children with neuropsychiatric disorders Ruth Van Hecke, Frederik J.A. Deconinck, Emmely Van Acker, Maya Danneels, Ingeborg Dhooge, Hilde Van Waelvelde, Jan R. Wiersema, Leen Maes, the integrity of the peripheral vestibular organ in children diagnosed with NDD was studied[7]. Our study of the sensitivity and reactivity of the vestibular analyzer in healthy children opens up opportunities for comparative studies in the future.

The vestibular system, which includes the semicircular canals and otolith organs, is one of the first sensory systems to develop and plays an important role in maintaining balance and spatial orientation [8-10]. Therefore, the conclusion that nystagmus thresholds in children under 7 years of age are in the range of 8-24 rad/s, and that thresholds increase from 3 to 30 rad/s with age, allowing a minimum angular velocity of 30 rad/s to be used for clinical examination, is important to take into account in other related studies.

The data obtained indicate that, along with the incomplete development of the vestibular analyzer, its connections, and the central nervous system, the inhibitory effect on the analyzer is very significant. With increasing age, excitatory processes become more intense, which leads to increased sensitivity and reactivity of the vestibular analyzer.

CONCLUSIONS

Nystagmus thresholds in children under 7 years of age are within the range of 8–24 rad/s, with thresholds increasing from 3 to 30 rad/s with age, allowing a minimum angular velocity of 30 rad/s to be adopted for clinical examination.

The sensitivity and reactivity of the vestibular analyzer increase with age.

The lowest sensitivity and reactivity of the vestibular analyzer are observed in children younger than 5 years old, and the highest in children older than 7 years old, which coincides with the development of the vestibular analyzer and the central nervous system.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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