

THE INFLUENCE OF EYE MOVEMENT AND THE VESTIBULAR-OCULAR REFLEX IN READING AND WRITING

A influência da oculomotricidade e do reflexo-vestíbulo-ocular na leitura e escrita

Renata Sales⁽¹⁾, José Fernando Colafêmina⁽¹⁾

ABSTRACT

Purpose: to determine whether changes in eye movement and vestibular-ocular reflex are related to the difficulty of reading and writing. **Methods:** we selected 18 subjects of both genders, aged between nine and 14 years of age with hearing and static visual acuity within the normality's standars, with a group of 11 subjects with difficulty of reading and writing and another control group of seven subjects without the difficulty. The exams were the evaluations of written language, static and dynamic visual acuity, audiological and eye movements. **Results:** static visual acuity, calibration, spontaneous nystagmus and semi - spontaneous were within the normality's standars throughout the study population. Tests of dynamic visual acuity and saccades showed statistically significant difference ($p < 0.05$) between the groups, while the pendular tracking showed changes in both groups, with no statistical difference. **Conclusion:** changes of saccadic and pendular tracking eye movements as well as poor performance of the vestibular-ocular reflex may be interfering with the difficulty of reading and writing development.

KEYWORDS: Reading; Writing; Saccades; Visual Acuity

■ INTRODUCTION

Reading and writing are complex activities composed of multiple interdependent processes involving motor and cognitive abilities, requiring the subject to appropriate action in writing and decodification competence of words while reading¹⁻³. Skills visuomotor perception are necessary in this task, coordinating visual information with motor programming of the subject⁴.

Studies show the great influence of biological, neuropsychological, psychosocial, educational, psychomotor, among others, in the process of acquiring reading and writing^{3,5}.

Currently, studies report the importance of the movement of the ocular globe for learning of reading and writing⁶⁻¹⁰, not based only on visual screening of

Brazilian schools that aim to identify student's visual acuity¹¹⁻¹³. Reading and writing require visuomotor skills, characterized by alternate saccadic, smooth-pursuit eye movements and fixations⁹.

Saccadic movements are responsible for the rapid movement of the ocular globe from one point to another, while the smooth-pursuit eye movements is characterized by eye tracking objects that pass slowly and the fixation is the permanence of looking at a specific point^{7,14}.

To obtain an accurate image is required stabilization in the retina, with or without head movement. During head movements, there is the integration of the vestibular system with extra-ocular muscles, resulting in a compensatory eye movement of equal velocity and in the opposite direction to the head movement, a phenomenon called vestibular-ocular reflex (VOR)¹⁴⁻¹⁷. Alterations in the oculomotor system, the velocity of the eyes in the opposite direction of the head does not reach the same speed of head movement, due to the deficit of VOR^{14,18,19}, resulting in blurring of viewed images²⁰.

Addition, to visually monitor the teacher in the classroom, performe concentration activities as

⁽¹⁾ Faculdade de Medicina de Ribeirão Preto - USP, São Paulo, SP, Brasil.

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well as the very action of writing and reading, is fundamental integrity of oculomotor function and vestibular interconnections^{14,21}.

Brazil faces major problems with alphabetization, denounced the high rate of illiteracy. According to the Brazilian Institute of Geography and Statistics of 2008, indicated almost 15 million people over 15 years old who can not read, nor, even, write a note²². Therefore, government statistics show that in Brazil the difficulty of reading and writing persists as an educational problem has not surpassed²³.

The importance of knowing how to read and write and use these skills in different situations of everyday life is an unquestionable reality and on the problematic of this difficulty, this study aimed to determine if the eye movement and VOR behavior interfere with the development of reading and writing.

■ METHODS

The study was descriptive and experimental type, approved by the Research Ethics Committee of Hospital Clinical, Faculty of Medicine of Ribeirão Preto - University of São Paulo under the Protocol 6726/2007. All subjects of study (students and their parents) participated voluntarily after proper guidance and signing the consent form.

The sample consisted of 18 subjects of both genders, of which 11 presented reading and writing difficulty (RWD) and seven had no such difficulty (control group). The subjects attended the 5th grade of elementary school, afternoon, in the State School Teacher Gleite of Alcantara, in the city of Ribeirão Preto/SP. The inclusion of subjects with RWD was taken by informing the teacher of the discipline of Portuguese school team. Exclusion criteria were tonal threshold audiometry outside normal limits (thresholds below 25 dB), middle ear disorders confirmed the impedance and static visual acuity (SVA) lowered (below 0.8 arc minutes on the Snellen eye chart).

The RDW was confirmed after anamnesis with parents and written communication evaluation of each subject. The subjects of the study were submitted assessments of SVA, dynamic visual acuity (AVD), written language, auditory (tonal threshold audiometry and impedanciometry) and eye movements.

The SVA evaluation was performed with the Snellen eye chart. The subject sat at a distance of 10 feet from the eye chart and it should inform the direction of each letter «E» that was present in the table. The letters «E» was gradually decreasing in size, the threshold of the SVA of the subject being recorded. The test was conducted by closed one

eye with a disc, the threshold is recorded and subsequently the other eye was closed for obtain the threshold of each eye.

The DVA was performed with the same material and technique of SVA, but in search of finding visual thresholds, the subject was oriented to move the head in the horizontal plane with both eyes open on the beat of clapping performed by the evaluator. Initially, the beats were of low frequencies, being gradually increased, with three frequencies and each was recorded visual threshold.

The evaluation of written language was based on writing the name and words, copying words, reading comprehension and reading. The results were described in the protocol and analyzed according to the expected age of the subject.

The auditory system was evaluated by means of pure tone audiometry for the purpose of registering the hearing thresholds and the impedanciometry for verifying the middle ear integrity.

The eye movement was assessed with the polygraph equipment Alvar brand, three electrodes being placed on the face of the subject beyond the ground wire, one on each side of the eye, one in forehead and ground wire above the forehead electrode. The eye movement tests were performed calibration, spontaneous and semi - spontaneous nystagmus beyond the saccades. In all tests the subject was instructed to fix their gaze on the lights that appear in the Maltese cross in front without making head movement.

Calibration was necessary for the subject to look away at 10 degrees to view from one point to another, so that each degree of gaze deviation corresponded to an inscription two inches tall by needle polygraph and recorded on graph paper. Calibration was made with the Maltese cross in the horizontal and vertical plane and the speed of the recording paper was 10 mm/s.

In proof of spontaneous nystagmus with eyes open the subject was instructed to fix their gaze on the lights that appear in front of him and later was to remain for 20 seconds with eyes closed for observation of spontaneous nystagmus with eyes open and closed. In assessing the semi-spontaneous nystagmus in the horizontal plane, the same guidelines were made, but the look should deflect 30 degrees to the right, left, up and down to follow up that occurred with the look of the lights.

In the saccadic movement, the subject should follow up with the look of your finger evaluator who was raised sporadically at random points in the horizontal plane and in the proof of nystagmus, the subject should follow with his eyes the pendulum motion in front of you.

The graphical response of eye movements during oculomotor tests was recorded on graph paper on this equipment.

The data were statistically analyzed with GraphPad Prism Program, version 6.0 to obtain the results. Depending on the nature of the variables, the nonparametric Mann-Whitney test was applied. The confidence limit was 95 % and the significance level (p) set at 0.05 or 5 %.

■ RESULTS

The study population consisted of 18 subjects of both genders, with nine males and nine females, showing a homogeneous group. Their ages ranged from nine to 14 years old, with a mean of 11.1 years of age.

The evaluation of written language showed that subjects indicated by Portuguese teacher of the school (11 subjects) that actually had difficulty reading and writing, showing deficit in writing the name and words, copying words, reading and reading comprehension.

In conducting the SVA, all subjects showed visual thresholds above 0.8 arc min and review all hearing thresholds above 25 dB hearing level were found, being considered within normal limits, with tympanogram type A and being stapedial reflexes

ipsilateral and contra lateral, indicative of integrity in the middle ear.

As the DVA, the results showed that 100 % of the control group had the identical to the SVA visual thresholds at all frequencies beats palms or at most one line below in Snellen chart compared to the threshold of SVA, with an informative finding normality of AVD. In the group with RWD there was a statistically significant percentage of change ($p < 0.05$) in the AVD (table 1), with reduction of the visual threshold more than two lines of Snellen chart below threshold in SVA.

Oculomotor tests performed, it was verified a regular calibration and absence of spontaneous nystagmus with eyes open and semi-spontaneous horizontally at 100 % of the population, indicating normality of same.

As for the saccade, Table 2 showed statistical difference ($p < 0.05$) between the results of the control group and RWD. In RWD group, the results reported difficulty in visual tracking with fixed head, with irregularity in the movement of the ocular globe in tracings recorded.

The smooth-pursuit eye movement was not statistically significant ($p < 0.05$) between the groups analyzed. The work considered as normal smooth-pursuit eye movement called type I offers regular morphology and type II, III and IV were considered abnormal, irregularities in the trace can be viewed.

Table 1 - Comparison of Dynamic Visual Acuity results between groups

Groups	Number of subjects	Normal results DVA ¹	Abnormal results DVA ¹
Control	07	07 (100%)	0 (0%)
RWD ²	11	05 (45,5%)	06 (54,5%)
Total	18	12	06

¹ DVA: dynamic visual acuity

² RWD: reading and writing difficulty

Non-parametric Test Mann-Whitney ($p=0,0345$)

■ DISCUSSION

Changes in language development and learning have varied causes and not only related to neurological factors and therefore the importance of adequate research in search of accurate diagnosis so you can make an efficient treatment ²⁴.

Children with learning disorders have deficit in oculomotor tests compared with children without

complaints ⁷, agreeing with the results of this study showed a high rate of change on tests of saccadic and smooth-pursuit eye movements that are required to perform a reading.

The calibration test is intended to evaluate the efficiency of the control of the central nervous system on eye movement, as well as spontaneous and semi-spontaneous nystagmus ²⁵. The findings of this study showed normality of these tests in the

Table 2 - Comparison of results between saccadic groups

Groups	Number of subjects	Normal results saccadic	Abnormal resultados saccadic
Control	07 (39%)	05 (71,5%)	0 (0%)
RWD ¹	11 (61%)	02 (28,5%)	11 (100%)
Total	18	07	11

¹RWD: reading and writing difficulty
Non-parametricTest Mann-Whitney (p=0,0025)

Table 3 - Comparison of smooth-pursuit eye movement results between groups

Groups	Number of subjects	Normal results smooth-pursuit	Abnormal results smooth-pursuit
Control	07 (39%)	02 (27%)	05 (73%)
RWD ¹	11 (61%)	03 (45,5%)	08 (54,5%)
Total	18	05	13

¹RWD: reading and writing difficulty
Non-parametricTest Mann-Whitney (p>0.9999)

control and RWD group, discarding central impairments that can be raised with the results of oculomotor tests.

The saccade is the fastest eye movement, easy to evaluate the clinical routine, being held to find a target in space. The registration of saccadic abnormalities is important to help diagnose related with various central nervous system pathologies, involving oculomotor areas ²⁶.

The saccadic pathway involves regions of the cerebral cortex, cerebellum and brainstem and few disorders affecting the central nervous system can not be detected in the saccadic eye movement record ²⁷. The unanimous alteration of saccades in RWD group showed the difficulty of these subjects to track a target in space, and may have difficulty in reading and writing, they are skills that require eye movements in search of letters on paper ^{7,14}.

Although the clarity of the relationship of saccadic movement in reading and writing, the literature shows a lack of studies relating the oculomotor saccadic movement while reading ⁶, which interfered with the comparison of the results of this study with similar studies.

Smooth-pursuit as saccades eye movements are oculomotor tests that require attention ^{28,29}, something generally deficient in children with reading and writing ³⁰, being observed this lack of attention on subjects participating in the present study.

In the smooth-pursuit eye movement, the work showed no statistical difference (p < 0.005) between the groups, agreeing with the results of the work of Ventura et al., 2009 ¹⁰, reporting the importance of

attention in this oculomotor test, but found no significant results between the groups with and without learning disabilities.

Changes in saccadic and smooth-pursuit eye movement interferes respectively to minimize the error and retinal slip reduction of the retinal image during eye movements ²⁶. These errors arising from low functioning saccade or smooth-pursuit eye movement interfere in the act of reading and writing ⁹, confirming the findings of this study that observed changes both in smooth-pursuit and saccades in the RWD group, showing statistical difference (p < 0.05) in the responses of saccades between the control and RWD group.

The difficulty of reading can be directly related to visual information processing, attention, visual-spatial, skills visual-motor integration ⁴ and control eye movements during the act of reading ^{6,8-10,31}. Considering the factors described and compared to the results of this study, oculomotor change in RWD group may have been a decisive factor for bad school performance.

As the movement of the ocular globe, the integrity of the visual pathways is a pre-requisite for the development of reading and writing ^{7,31}. The functioning of the visual pathways was assessed by SVA, showing that the entire population of this study showed no changes in visual acuity without head movement, not being a SVA, a problem for learning the skills of reading and writing in the groups analyzed.

The constant movement of the head of the students in the classroom should not affect the stabilization of images on the retina, in other words, the VOR must remain functioning. Studies show

that no image stabilization in routine leads to visual blurring and consequently the subjects lose postural balance and quality of life because they see the world always moving³²⁻³⁴. In the act of reading and writing is required integrity of VOR and with it the subject can move around and view objects concurrently without difficulty²¹. In the present study, proof of DVA was evaluative VOR as well as in other studies³⁵⁻³⁷. The high percentage index of subjects who showed changes in VOR in RWD group suggests that reflex direct connection with the development of reading and writing.

Oculomotor and VOR alterations are considered neurotological problems¹⁴ and study reveals that saccadic and smooth-pursuit eye movements are irregular in population neurotological complaints compared to the population without complaint³⁸. The RWD group presented deficit VOR followed by oculomotor alteration, showing up with a group otoneurologic commitment.

Given the importance of school learning to reduce the number of dropout students and inserting them into the labor market is clear need for more scientific research to confirm the data obtained in this study, the reasons for the improving relationship between oculomotricity and VOR in reading and writing.

The confirmation of the influence of eye movement and the VOR in learning and development of reading and writing will be of paramount importance in the educational field, as evaluation measures to assist in diagnosis may be present in schools under the responsibility of an expert professional and proper treatment will lead to the development the reading – writing process.

■ CONCLUSION

Among the causes of difficulties in performing reading and writing, the study revealed that the eye movement and the vestibular-ocular reflex may also be interfering with the difficulty of the development of reading and writing, the presence of a qualified professional to perform oculomotor and evaluative evidence is needed the vestibular- ocular reflex in the school .

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RESUMO

Objetivo: verificar se alterações na oculomotricidade e no reflexo vestibulo-ocular estão relacionados com a dificuldade de leitura e escrita. **Métodos:** foram selecionados 18 sujeitos de ambos os gêneros, faixa etária entre nove e 14 anos de idade, com audição e acuidade visual estática dentro dos padrões de normalidade, sendo um grupo de 11 sujeitos com dificuldade de leitura e escrita e outro grupo controle composto por sete sujeitos sem a dificuldade. Os exames realizados foram avaliações da linguagem escrita, acuidade visual estática, acuidade visual dinâmica, audiológica e oculomotricidade. **Resultados:** a acuidade visual estática, calibração, nistagmo espontâneo e semi - espontâneo apresentaram-se dentro da normalidade em toda população estudada. As provas de acuidade visual dinâmica e movimento sacádico apresentaram diferença estatisticamente significativa ($p < 0,05$) entre os grupos estudados, enquanto o movimento de rastreamento apresentou alterações em ambos os grupos, não ocorrendo diferença estatística. **Conclusão:** alterações na oculomotricidade, assim como mal desempenho do reflexo vestibulo-ocular mostrado na acuidade visual dinâmica podem estar interferindo na dificuldade do desenvolvimento da leitura e escrita.

DESCRITORES: Leitura; Escrita; Movimentos Sacádicos; Acuidade Visual

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Mailing address:

Renata Sales

Rua José de Alencar, 1913 – Vila Tamandaré

Ribeirão Preto – SP – Brasil

CEP: 14085-560

E-mail: fono.otn@hotmail.com