Visual control in children with developmental dyslexia

Controle visual em crianças com dislexia do desenvolvimento

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ABSTRACT

Purpose: To assess binocular control in children with dyslexia. **Methods:** Cross-sectional study with 26 children who were submitted to a set of ophthalmologic and visual tests. **Results:** In the dyslexic children less eye movement control in voluntary convergence and unstable binocular fixation was observed. **Conclusion:** The results support the hypothesis that developmental dyslexia might present deficits which involve the magnocellular pathway and a part of the posterior cortical attentional network.

Keywords: Dyslexia/physiopathology; Attention; Vision, binocular/physiology; Visual perception; Ocular motility disorders; Learning disorders

INTRODUCTION

Developmental dyslexia is a specific neurological condition affecting the reading learning process, with academic performance below expected levels in relation to chronological age, which is unexplainable by any kind of general intelligence deficit, lack of learning opportunities, general motivation or sensory dysfunction. Its origin is genetic, with anatomical studies demonstrating intrauterine neurological alterations[1]. The most frequent signs include deficits in language acquisition, slow reading, difficulty in expressive language and in the ability to apprehend grapheme/phoneme correspondence, difficulty in understanding and memorizing reading content, inversions, omissions or substitution of letters and/or syllables in words while reading and writing[2-3].

The most accepted hypothesis to explain the problems derived from developmental dyslexia is the phonological deficit theory. It states that the core cognitive deficit lies in the ability to represent or recall speech sounds, but this theory does not explain visual, sensorial and motor coordination deficits that can occur in dyslexia[4]. The visual theory does not exclude a phonological deficit, but it emphasizes a contribution of one of the visual pathways, namely the magnocellular[5-6]. This theory contends that in people with dyslexia the magnocellular system is abnormal, causing difficulties in some aspects of visual perception and in binocular control, which may cause reading impairment.

The magnocellular pathway, also called dorsal or "where" pathway, directed toward parietal and frontal lobe, begins in the big ganglionary cells of the retina[7-9]. Neurons in these pathways have distinct physiological properties from the small parvocellular cells in the ventral or "what" pathway. The neurons in the magnocellular way have larger receptive fields, respond in a transient and fast fashion, have broadband wavelength sensitivity, prefer low spatial frequencies and are sensitive to low-contrast stimuli[10]. Because of its relationship with the posterior parietal cortex, the dorsal stream has been related to the process of space relations and vi-

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Recebido para publicação em 31.03.2008
Última versão recebida em 28.08.2008
Aprovação em 18.09.2008

sually guided movements, spatial attention and eye movement[11], binocular control[12], and visual-space attention[13-14]. An important number of dyslexic individuals show anomalous standards of saccadic movements[15], instability of binocular fixation and reduced vergence[16-18].

The aim of this study was to evaluate visual processing in children with developmental dyslexia, using ophthalmologic tests, with emphasis on binocular control and, by doing so, observe any evidence of impaired magnocellular pathway performance.

METHODS

A transversal study was done involving 26 children, separated in to two different groups. Group 1: thirteen children with previous diagnosis of developmental dyslexia using the following criteria: intelligence coefficient compatible with normality, using Wechsler Intelligence Scale for Children (WISC), reading retardation of least 18 months, aged between 8 and 13 years, were recruited from the Laboratory of Learning Disabilities of College of Medical Sciences, of the State University of Campinas. Group 2: thirteen children age-matched, classified as normal readers with appropriate reading and academic level were invited from public schools in the area. Criteria of exclusion for both groups: auditory deficiency, significant neurological disease (epilepsy, head injury), ophthalmologic disorders such as strabismus or low vision and use of medication that interferes with the cognitive process. The research was approved by the Committee of Ethics on Research of the Faculty of Medical Sciences, State University of Campinas (UNICAMP) and all the responsible for the subjects included in the study read and signed an informed consent.

The dyslexic group (G1) consisted of 4 girls and 9 boys with an average age of 11 years, (mean age 11 years 2 months, SD 16 months, range: 8, 5-13, 2) and the control group (G2) was formed by 7 girls and 6 boys at an average age of 11 years (mean age 11 years 2 months, SD 19 months, range: 8, 1-13, 3) The procedures were carried out by the Laboratory of Learning Disabilities (DISAPRE) and the Department of Ophthalmology of UNICAMP.

Initially, both samples were submitted to ophthalmologic assessment: ocular refraction, biomicroscopy and fundoscopy. Refractive error measurement was carried out 40 minutes after cycloplegia with 1% cyclopentolate instilled two times (at 0 and 5 minutes) before refraction by retinoscopy: refractive error was considered significant when hypermetropy was above +2,00 SD, myopia above 0,75 SD, astigmatism above 1 CD between the prime meridians, and astigmatism in 0,75 interocular difference above 1 D. Vision assessment was performed on another day with refractive correction: uniocular visual acuity was tested for near and distant using the Lea Symbols tables for 40 cm and 3 meters (Good Lite 250800 and 257000®), contrast sensitivity test was performed using CSV - 1000 HGT® (Vector Vision, Dayton, OH, USA), colour vision with Ishihara® plates and stereoscopic acuity with Titmus® stereo test. Assessment of ocular dominance and handedness. Accommodation assessment: accommodative convergence/accommodation (AC/A) ratio was assessed using the gradient method and the near point of accommodation. Assessment of ocular alignment: prism and cover test performed at 4 meters and 33 centimeters. Assessment of eye movements: versions, near point of convergence, fusion range with isolated prisms and fusion range at synoptophore with large slides (7°) and small (2 1/2°) fusion targets and physiological diplopia.

Statistical data were verified by the SPSS program (Statistical Package for Social Sciences version 14), for two independent samples, Mann-Whitney U test, two tailed, corrected for ties. The level of significance required to support the hypothesis was established as $P \leq 0.05$.

RESULTS

Ophthalmologic examination: Two participants were reported: a dyslexic participant with OD -0.50 CD 180º and OS +0.50 SD with -3.50 CD 180º, and one of the control group had hypermetropy +2.50 SD in one eye and 2.00 SD in the other eye. Biomicroscopy and fundoscopy were similar in both groups.

Visual assessment

Visual acuity (VA): Except for one dyslexic individual who presented anisometropia with VA distance OD 20/25, OS 20/25, near OD 20/25, OS 20/30, all others showed a monocular VA, distant or near, equal or better than 20/20.

Contrast sensitivity and color vision: the performance of both groups was similar, without alterations. Stereoscopic acuity: in both groups the results were normal (40 seconds of arc).

Accommodation assessment: The medians of the near point of accommodation were 9 centimeters in both groups (p=0,978 for the right eye and p=0,411 for the left eye). The medians of the AC/A ratio were 3^{Δ}/SD for the dyslexic group, and 4^{Δ}/SD for the control group.

Ocular and motor dominance

Ocular dominance and handedness: In both groups there was dominance of the right eye in 62% (8 participants in each group). Right-handedness occurred in 85% (11) of the dyslexic group and in 92% (12) of the control group. Crossed dominance (right eye/left hand or left eye/right hand) occurred in 40% (5) of the dyslexic group and in 31% (4) of the control group.

Assessment of ocular alignment

In the prism and cover test, only one participant of the dyslexic group presented exophoria for a distance of 4 meters (6^{Δ}) the remaining ones did not show any deviation. For a distance of 33 centimeters, 3 participants in the dyslexic group presented exophoria to 6^{Δ} and two exophorias from 10^{Δ} to 12^{Δ}.

In the control sample, 4 children showed exophoria 2Δ and 1 with 8Δ and the remaining ones did not show any phoria.

Assessment of eye movements

Versions: only 1 participant, from the dyslexic group showed alteration: double hyperfunction of the inferior oblique muscle (+1).

Fusion range: the evaluation was done with isolated prism using optotype acuity 20/40 as fixation target. In the fusion divergence, base in, there was no significant difference between the groups. Distance and near fusion convergence, base out (Figures 1 and 2), had different results.

Near point of convergence and fusion range at synotophore: were similar for both groups.

Physiological diplopia: all the participants were able to recognize the homonymous diplopia (fixing near target) and the crossed diplopia (fixing the distant target). Fixing the near target, dyslexic children were not able to maintain steady fixation (Figure 3).

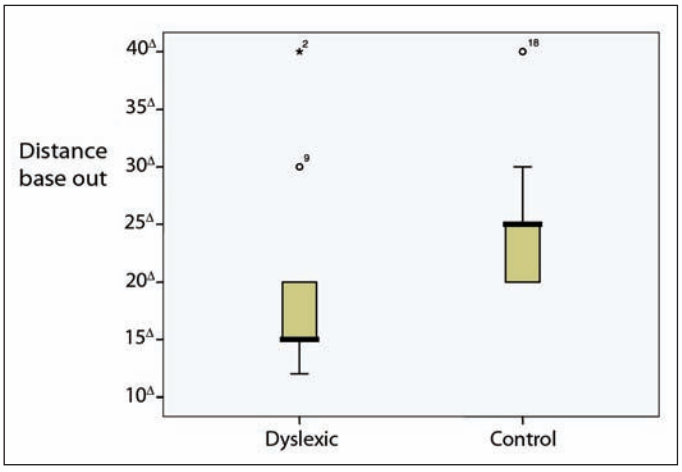

Figure 1 - Distance fusion range isolated base out prisms: the distance fusion range with prisms base out (convergence) showed median of 15Δ (range: 12Δ - 40Δ) in the dyslexic group and 25Δ (range: 20Δ - 40Δ) in the control group (p=0.031)

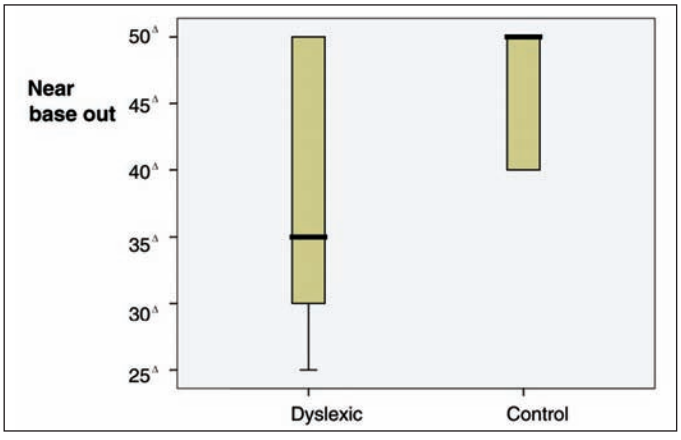

Figure 2 - Near fusion range isolated base out prisms: the near fusion range with prisms base out (convergence) showed a median of 35Δ (range: 25Δ - 40Δ) in the dyslexic group and 50Δ (range: 40Δ - 50Δ) in the control group (p=0.031)

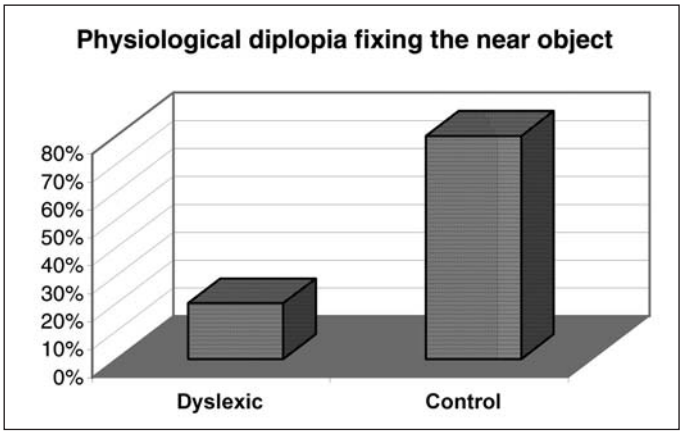

Figure 3 - Skill percentage in steady fixation with physiological diplopia: when stable fixation during ten seconds was requested, only 3 (20%) from the dyslexic group were able to maintain steady fixation in convergence, against 12 of the control group

DISCUSSION

The aim of this study was to analyze clinical visual assessment in children with dyslexia and those age-matched, with adequate reading skills. Almost all the tasks were not different for both groups, including local stereoscopic and color vision, which corroborates similar data[16,19]. In this sample, predominance of left handedness was not found and crossed dominance was practically equal in both groups[20].

Nevertheless, two differences were found. In the assessment of convergence with isolated prisms the dyslexic group had a worse performance. The convergence serves not only to bring the eyes to adequate alignment, but also to keep such alignment[21] during which visual information is retrieved in order for the written text to be decoded. Low fusional amplitude has been found in dyslexic individuals[16-17,22]. In one study[20], 12% of dyslexic individuals showed insufficient convergence against 2% in the control group. In another study[18], the group with dyslexia showed a poorer performance in fixation tests and vergencial control. Convergence fusion assessment with isolated prisms measures, at first, reflex vergence (when the bar of prisms was used), higher prismatic values demand superior voluntary effort[21]. Probably the voluntary convergence is elicited by the frontal cortex in frontal eye field (junction of precentral and superior frontal sulcus)[23]. This region receives visual inputs, produces movements of the eye and takes part in the dorsal stream for attention[24].

The physiological diplopia test evaluates visual system capacity to maintain ocular fixation and simultaneously pay attention to peripheral field stimulus. Attention is defined by the mental ability to select stimuli, responses or thoughts that are relevant to behavior from those that are not.

Psychological, functional, anatomical and neuronal analyses indicate that attentional processes are closely linked to

oculomotor processes involving activation of common areas in the parietal, frontal and temporal lobes[11]. Alterations in attention control in dyslexic children were demonstrated[25-26]. Others authors[25] associate visual processing with visual attention. In visual attention tests worse performance was observed in dyslexic individuals than in controls. Learning to read involves training for rapid attentional shifts, associated with eye movements, along the sequential letters and words in a line[26]. In this process the integrity of the parietal lobe seems essential.

These findings suggest that development dyslexia might involve impairments in a network of cortical areas, a weakness of the magnocellular pathway that provides input to the posterior cortical attentional network and, at the same time, are involved in eye movement control.

ACKNOWLEDGEMENTS

We are grateful to the dyslexic and control participants and their parents.

RESUMO

Objetivo: Avaliar o controle binocular em crianças com dislexia. **Métodos:** Estudo transversal do qual participaram 26 crianças, nas quais foram aplicadas uma série de exames oftalmológicos e visuais. **Resultados:** Nas crianças com dislexia observou-se controle menor na convergência voluntária e na estabilidade da fixação binocular. **Conclusão:** Os resultados apóiam a hipótese de que na dislexia do desenvolvimento podem ocorrer déficits que envolvem a via visual magnocelular e uma parte da rede cortical posterior da atenção.

Descritores: Dislexia/fisiopatologia; Atenção; Visão binocular/fisiologia; Percepção visual; Transtornos da motilidade ocular; Transtornos de aprendizagem

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