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THERAPEUTIC MANAGEMENT OF DYSLEXIA

MANEJO TERAPÊUTICO DA DISLEXIA

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ABSTRACT

Dyslexia is a specific learning disorder of neurobiological origin that primarily affects reading fluency, word decoding, and spelling skills, and is associated with functional and structural alterations in neural networks responsible for phonological processing. The present study aimed to analyze recent scientific evidence regarding the therapeutic management of dyslexia. This is a narrative bibliographic review conducted using the PubMed database, employing the descriptors dyslexia, treatment, and diagnosis, combined with Boolean operators. Articles published in the last five years, available in full text in Portuguese or English, and directly related to the topic were included. The results indicate that dyslexia has a heterogeneous etiology, involving deficits in phonological, visual, and auditory processing, making accurate differential diagnosis essential to guide effective therapeutic interventions. Educational programs based on phonological training remain the most widely used approach, although they show moderate effects. In this context, personalized therapeutic strategies, based on the identification of specific cognitive mechanisms, demonstrate greater potential effectiveness. Emerging technologies, such as non-invasive brain stimulation and artificial intelligence-based tools, have expanded diagnostic and therapeutic possibilities. It is concluded that dyslexia management should involve a multidimensional approach, integrating educational interventions, technological advances, and psychosocial support, with the aim of improving academic performance and promoting cognitive health throughout life.

Keywords: Dyslexia. Learning Disorders. Diagnosis. Treatment. Neuroscience.

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RESUMO

A dislexia é um transtorno específico de aprendizagem de origem neurobiológica que compromete principalmente a fluidez da leitura, a decodificação de palavras e as habilidades de soletração, estando associada a alterações funcionais e estruturais em redes neurais responsáveis pelo processamento fonológico. O presente estudo teve como objetivo analisar as evidências científicas recentes acerca do manejo terapêutico da dislexia. Trata-se de uma revisão bibliográfica narrativa realizada na base de dados PubMed, utilizando os descritores dyslexia, treatment e diagnosis, combinados por operadores booleanos. Foram incluídos artigos publicados nos últimos cinco anos, disponíveis na íntegra nos idiomas português ou inglês e diretamente relacionados ao tema. Os resultados indicam que a dislexia apresenta etiologia heterogênea, envolvendo déficits no processamento fonológico, visual e auditivo, o que torna essencial a realização de diagnóstico diferencial preciso para orientar intervenções terapêuticas eficazes. Programas educacionais baseados em treinamento fonológico permanecem como a abordagem mais utilizada, embora apresentem efeitos moderados. Nesse contexto, estratégias terapêuticas personalizadas, fundamentadas na identificação dos mecanismos cognitivos específicos, demonstram maior potencial de eficácia. Tecnologias emergentes, como a estimulação cerebral não invasiva e ferramentas baseadas em inteligência artificial, têm ampliado as possibilidades diagnósticas e terapêuticas. Conclui-se que o manejo da dislexia deve envolver abordagem multidimensional, integrando intervenções educacionais, avanços tecnológicos e suporte psicossocial, com o objetivo de melhorar o desempenho acadêmico e promover a saúde cognitiva ao longo da vida.

Palavras-chave: Dislexia. Transtornos de Aprendizagem. Diagnóstico. Tratamento. Neurociência.

RESUMEN

La dislexia es un trastorno específico del aprendizaje de origen neurobiológico que afecta principalmente la fluidez lectora, la decodificación de palabras y las habilidades de ortografía, estando asociada a alteraciones funcionales y estructurales en redes neuronales responsables del procesamiento fonológico. El presente estudio tuvo como objetivo analizar la evidencia científica reciente acerca del manejo terapéutico de la dislexia. Se trata de una revisión bibliográfica narrativa realizada en la base de datos PubMed, utilizando los descriptores dyslexia, treatment y diagnosis, combinados mediante operadores booleanos. Se incluyeron artículos publicados en los últimos cinco años, disponibles en texto completo en portugués o inglés y directamente relacionados con el tema. Los resultados indican que la dislexia presenta una etiología heterogénea, que involucra déficits en el procesamiento fonológico, visual y auditivo, lo que hace esencial la realización de un diagnóstico diferencial preciso para orientar intervenciones terapéuticas eficaces. Los programas educativos basados en el entrenamiento fonológico siguen siendo el enfoque más utilizado, aunque presentan efectos moderados. En este contexto, las estrategias terapéuticas personalizadas, fundamentadas en la identificación de los mecanismos cognitivos específicos, demuestran un mayor potencial de eficacia. Tecnologías emergentes, como la estimulación cerebral no invasiva y herramientas basadas en inteligencia artificial, han ampliado las posibilidades diagnósticas y terapéuticas. Se concluye que el manejo de la dislexia debe implicar un enfoque multidimensional, integrando intervenciones educativas, avances tecnológicos y apoyo psicosocial, con el objetivo de mejorar el rendimiento académico y promover la salud cognitiva a lo largo de la vida.

Palabras clave: Dislexia. Trastornos del Aprendizaje. Diagnóstico. Tratamiento. Neurociencia.

1 INTRODUCTION

Dyslexia is characterized as a specific learning disorder, with a neurobiological basis, which primarily compromises fluidity in reading, word decoding, and spelling skills (Alkhurayyif and Sait, 2024). Associated with this, the exclusion of disorders or organic deficiencies that may cause similar or confounding symptoms is added to the diagnosis (WERTH, 2024). Neuroimaging studies indicate that dyslexic individuals present functional and structural alterations in critical neural networks, particularly in the left temporoparietal cortex, a fundamental area for phonological processing and visuospatial integration, compromising the association between graphemes and phonemes and the processing of pseudowords and unknown words (TURKER et al., 2025).

In addition, research in functional neuroimaging points to changes in connectivity between three key regions of reading development: the left temporoparietal cortex, the ventral occipitotemporal cortex, and the inferior frontal gyrus. The dysfunction in communication between them is associated with difficulty in automating reading and integrating visual and phonological processing (TURKER et al., 2025). With regard to the neurobiological bases, the left temporoparietal cortex (PCT) is consolidated in the literature as the main center of phonological decoding and sensory integration. According to Turker et al. (2025), this region demonstrates exceptional neural plasticity during the beginning of literacy, and its activation is directly correlated with reading performance in adults. In dyslexic individuals, the hypoactivity observed in PCT is not only a biological marker, but the point of origin of a cascade of failures in functional communication with frontal and occipital areas, hindering the fluid conversion of graphic symbols and sounds (Turker et al., 2025; Alkhurayyif; Sait, 2024)

Recently, the understanding of dyslexia has expanded beyond academic and childhood difficulties, revealing genetic and causal associations with increased risk for several forms of dementia, such as Alzheimer's disease and frontotemporal dementia, suggesting that the disorder shares biological architectures with neurodegeneration (Zhu et al., 2024). Since reading is one of the neuroprotective factors against the development of neurodegenerative diseases, language impairment is exposed as a factor to be investigated at risk of these pathologies and, in addition, language difficulty may be one of the first clinical signs evaluated in the practical presentation of these conditions (Zhu et al., 2024).

Historically, dyslexia management has focused on the medical model of "cure" or "correct," but the neurodiversity movement proposes a paradigm shift toward therapies informed by acceptance of neurological difference, prioritizing the construction of ecological niches that support the individual rather than just eliminating symptoms (Chapman and Botha, 2022). Early diagnosis is vital, and the advent of artificial intelligence (AI) has enabled the creation of automated tools based on electroencephalography (EEG) and handwriting analysis to identify the disorder with greater accuracy (Alkhurayyif and Sait, 2024). Given the heterogeneity of the causes — which can involve everything from phonological deficits to ocular motor control problems — treatment requires personalized and multimodal approaches (Werth, 2024).

2 METHODOLOGY

The present study is characterized as a narrative literature review, developed with the objective of synthesizing and analyzing the most recent scientific evidence related to the Therapeutic Management of Dyslexia. The search was carried out in the PubMed database, using the descriptors "Dyslexia", "Treatment" and "Diagnosis", combined through the Boolean operators AND and OR, according to the Medical Subject Headings (MeSH) terminology. Articles published in the last five years, available in full and written in Portuguese or English, that directly addressed the topic, were included. Studies that did not have a direct relationship with the central theme, duplicate publications, narrative reviews with low methodological rigor, and articles not indexed in the database used were excluded. The selection of studies was conducted in two stages: screening of titles and abstracts, followed by the evaluation of full texts to confirm relevance. The information extracted was organized in a descriptive way.

3 RESULTS AND DISCUSSION:

3.1 ETIOLOGICAL HETEROGENEITY OF DYSLEXIA

Dyslexia is not a homogeneous condition, and may result from multiple cognitive and sensory deficits. Among the factors potentially involved are alterations in visual processing, visual attention deficits, difficulties in auditory processing and impairments in phonological awareness. The interaction between these factors makes it essential that the diagnosis includes the investigation of the specific causes of the reading difficulties presented by each individual. According to this perspective, standardized interventions

may have limited efficacy when they do not consider the mechanisms underlying the disorder (WERTH, 2024).

3.2 DIAGNOSTIC CHALLENGES AND SUBTYPES

The diagnosis of dyslexia requires a rigorous differential evaluation, since different impairments can lead to similar reading difficulties. Subtypes such as phonological dyslexia (difficulty converting graphemes into phonemes) and surface dyslexia (difficulty in visually recognizing irregular words) require different intervention strategies (Alkhurayyif and Sait, 2024; Bartha-Doering et al., 2024). In rare cases, surface dyslexia may be associated with structural malformations, such as agenesis of the corpus callosum, which reinforces the need for detailed clinical and neuropsychological examinations to guide treatment (Bartha-Doering et al., 2024). Werth (2024) argues that the diagnosis should identify the specific functional causes — such as visual attention or phonological processing disorders — for the training to be effective in the short term.

The heterogeneity of dyslexia requires the understanding that reading depends on "irreplaceable necessary conditions", as postulated by Werth (2024). In addition to phonological processing, the success of reading is conditioned by motor and sensory variables, such as the time of visual fixation and the limit of simultaneous recognition of letters. When these basic functions are compromised, such as in cases of hemianopic dyslexia or visual field disorders, traditional phonological training becomes ineffective, and it is necessary to replace pedagogical instruction with compensatory eye movement training that allows the individual to stabilize the visual focus on the text (Werth, 2024).

The clinical studies carried out contribute to a broad understanding of the various specific manifestations of dyslexia. An example is the case study described by Bartha-Doering et al. (2024), which looks at the cognitive performance of a 10-year-old child with complete agenesis of the corpus callosum and diagnosis of surface dyslexia and deep dysgraphia.

After performing a program aimed at spelling training, a significant improvement in its spelling accuracy, accuracy and reading speed was observed. In addition to behavioral improvements, neuroimaging studies indicated a strengthening of interhemispheric connectivity between occipital lobes, suggesting that specific interventions could promote functional changes in neural networks associated with reading.

3.3 EFFECTIVENESS OF CONVENTIONAL INTERVENTIONS

Educational programs focused on phonological instruction continue to be the most widely used therapeutic approach in the management of dyslexia. However, the results of systematic reviews indicated that the effects of these interventions are modest, which was evidenced in a meta-analysis of controlled studies on the efficacy of treatment in dyslexia, with an average effect size of around 0.38 (Toffalini et al., 2021). The difficulty in recruiting large samples and the variability in measurement methods often result in overestimation of the effects in small studies (Toffalini et al., 2021). However, intensive training programs focused on specific causes have demonstrated significant improvements in reading speed after few sessions, suggesting that diagnostic accuracy is the determining factor for successful rehabilitation (Werth, 2024). For surface dyslexia, interventions using the "reading box" method and focusing on the visual lexicon have been shown to be beneficial in stabilizing the reading of known and irregular words (Bartha-Doering et al., 2024).

In addition to traditional therapeutic approaches, recent literature highlights the importance of understanding dyslexia as a multifactorial disorder, in which different cognitive deficits can coexist and influence reading performance. In this sense, Werth (2024) argues that standardized interventions tend to have limited effectiveness when they do not consider the specific mechanisms underlying each individual's difficulties. This perspective is reinforced by studies that demonstrate that different subtypes of dyslexia require different therapeutic strategies, as occurs in phonological dyslexia and surface dyslexia, whose deficits involve, respectively, difficulties in grapheme-phoneme conversion and visual recognition of irregular words (ALKHURAYYIF; SAIT, 2024; BARTHA-DOERING et al., 2024).

Studies have shown comparative data between traditional interventions and modern approaches, which stimulate improvement in reading through an improvement in visual ability and use video games. However, the effectiveness between the different techniques was similar (TOFFALINI et al., 2021). In this context, evidence indicates that interventions targeting specific deficits can promote more efficient improvements in the

significant in reading performance when compared to generalist programs (WERTH, 2024). However, systematic reviews indicate that the average efficacy of educational interventions still remains moderate, with a relatively small effect size in

controlled studies, which highlights the need for more robust research methodologies and larger samples to adequately assess therapeutic outcomes (TOFFALINI et al., 2021).

Despite this, the results should be interpreted with caution due to frequent methodological limitations, such as small sample sizes and the extensive use of multiple statistical tests. From this perspective, the authors suggest future research that uses repeated measures of evaluation over time and a more robust statistical model, in order to more accurately assess the effects of interventions on the individual's reading performance. (Toffalini et al., 2021).

3.4 NEUROMODULATION AND EMERGING TECHNOLOGIES

A promising frontier in therapeutic management is the use of transcranial direct current stimulation (tDCS). The application of anodal tDCS over the left temporoparietal cortex not only improves immediate performance in reading pseudowords, but also alters functional connectivity within reading networks, increasing communication between the temporoparietal and occipitotemporal areas (Turker et al., 2024). In addition to stimulation, AI has been applied to detect subtle patterns in neuroimaging (fMRI) and EEG data, enabling faster diagnoses and the personalization of training applications based on deep learning algorithms (Alkhurayyif and Sait, 2024).

In addition, recent advances in the areas of neuroscience and technology have broadened the diagnostic and therapeutic perspectives of dyslexia. Studies have shown that neuromodulation techniques, such as transcranial direct current stimulation, can favor the functional reorganization of neural networks associated with reading processing (TURKER et al., 2024). At the same time, tools based on artificial intelligence have been used to identify neurophysiological patterns related to the disorder, contributing to earlier diagnoses and the development of personalized interventions (ALKHURAYYIF; SAIT, 2024).

Finally, the contemporary approach to neurodiversity proposes an expansion of the therapeutic focus, valuing not only the remediation of reading difficulties, but also the adaptation of the educational and social environment to the needs of the dyslexic individual. This perspective emphasizes the importance of inclusive pedagogical strategies, assistive technologies, and psychosocial support as fundamental components of disorder management (CHAPMAN; BOTHA, 2022).

3.5 ETHICAL AND SOCIAL PERSPECTIVES

The management of dyslexia has been influenced by the theory of neurodiversity, which criticizes excessive pathologization and the exclusive focus on "repairing" the individual. Neurodivergence-informed therapy emphasizes adaptation of the environment (such as the use of assistive technologies) and psychological support to cope with stigma, promoting the idea that neurological variation is part of human biodiversity and not just a flaw to be eradicated (Chapman and Botha, 2022). This view is supported by findings showing that cognitive and educational performance can mediate the risk of diseases such as Alzheimer's in dyslexics, suggesting that adequate educational and social support has long-term protective effects (Zhu et al., 2024).

In addition to academic difficulties directly related to reading and writing, dyslexia can also be associated with important psychological impacts throughout the individual's development. Recent evidence indicates that adolescents with dyslexia are at higher risk of the prevalence of symptoms of anxiety, depression, and other emotional difficulties, especially when comorbidities coexist, such as attention deficit hyperactivity disorder (ADHD) (Morte-Soriano & Soriano-Ferrer, 2024). These experiences can be intensified by social factors, such as stigmatization, misunderstanding of learning difficulties, and repeated experiences of school failure, reinforcing the importance of therapeutic approaches that also consider the psychological well-being and educational context of these individuals.

3.6 COGNITIVE IMPLICATIONS AND RISK OF NEURODEGENERATIVE DISEASES

According to ZHU et al. (2024), recent studies also suggest a possible relationship between dyslexia and neurodegenerative processes. The analyses demonstrated a causal association between genetic variants related to dyslexia and an increased risk of developing Alzheimer's disease. The authors also observed that part of this effect seems to be mediated by cognitive performance throughout life, indicating that factors such as cognitive stimulation and level of intellectual activity can modulate this relationship.

The author ZHU et al. (2024) points out that neurodegenerative diseases were investigated, in genetic and statistical analyses, regarding the correlation between dyslexia and these pathologies, and the causal relationship with vascular dementia (VD), frontotemporal dementia (FTD) and dementia with Lewy bodies was discarded. Thus, the finding of an association between increased risk of Alzheimer's disease (AD) and dyslexia

remains, but without an evident causal relationship. Concomitantly, it was seen that techniques to aid cognitive development, such as teaching mathematics, arithmetic and second language learning, worked as neuroprotective factors for the development of AD.

These findings reinforce the importance of educational and cognitively stimulating strategies, such as encouraging reading, which can contribute to the development of cognitive reserve and potentially reduce the risk of cognitive decline in the long term.

4 CONCLUSION

Dyslexia is a complex and heterogeneous learning disorder, resulting from the interaction of neurobiological, cognitive, and environmental factors. Alterations in the neural networks responsible for processing reading, particularly in the left temporoparietal cortex and in its connectivity with other cortical regions, play a central role in the phonological decoding difficulties observed in dyslexic individuals (TURKER et al., 2025).

In addition, the understanding of dyslexia has expanded beyond academic and childhood difficulties, revealing genetic and causal associations with increased risk for various forms of dementia, such as Alzheimer's disease and frontotemporal dementia, suggesting that the disorder shares biological architectures with neurodegeneration (Zhu et al., 2024).

Importantly, historically, dyslexia management has focused on the medical model of "cure" or "correct," but the neurodiversity movement proposes a paradigm shift toward therapies informed by the acceptance of neurological difference, prioritizing the construction of ecological niches that support the individual rather than just eliminating symptoms (Chapman and Botha, 2022).

Therefore, the therapeutic management of dyslexia requires a multidimensional approach that combines accurate differential diagnosis, evidence-based educational interventions, and strategies tailored to the individual needs of each patient. Although phonological training programs continue to be the main therapy used, evidence indicates that their effects tend to be moderate, reinforcing the importance of personalized interventions based on the identification of the specific cognitive mechanisms involved in each case (TOFFALINI et al., 2021; WERTH, 2024).

In addition to traditional approaches, neurostimulation and artificial intelligence technologies have expanded the diagnostic and therapeutic perspectives of dyslexia. Non-invasive brain stimulation techniques can modulate neural networks related to

reading, while tools based on machine learning favor earlier and more accurate diagnoses (ALKHURAYYIF; SAIT, 2024; TURKER et al., 2025).

In this sense, the adoption of a therapy informed by neurodiversity proposes that the "deficit" be seen as a relational phenomenon between the individual and a poorly adapted environment. Chapman and Botha (2022) argue that, instead of focusing exclusively on "cure" or eliminating symptoms, therapeutic management should prioritize the construction of ecological niches, using assistive technologies and pedagogical modifications. This paradigm shift shifts the burden of diagnosing intrinsic pathology to the need for support, promoting the acceptance of neurological difference and psychological well-being as inseparable pillars of treatment (Chapman; Botha, 2022).

Finally, advances in understanding the genetic and cognitive basis of dyslexia also point to possible lifelong implications of the disorder, including a possible relationship with neurodegenerative diseases. In this context, educational and cognitively stimulating interventions play a fundamental role not only in improving academic performance, but also in promoting long-term cognitive health (ZHU et al., 2024).

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