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Functional Predictors of Academic Performance in Portuguese in Children and Adolescents with Down Syndrome: A Documentary Study

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ABSTRACT

Down syndrome is a genetic condition associated with intellectual disability, characterized by variability in cognitive and adaptive functioning, directly impacting academic development, particularly literacy acquisition. Evidence indicates that adaptive functioning plays a central role in learning outcomes in this population. This study aimed to investigate the relationship between adaptive functioning and academic performance in Portuguese in children and adolescents with Down syndrome. This is a documentary, exploratory study conducted using secondary data from a specialized educational institution (ADID), following ethical standards applicable to this type of research. The sample consisted of 33 participants aged between 9 and 17 years ($M = 14$; $SD = 2.6$). Adaptive functioning was assessed using the International Classification of Functioning, Disability and Health (ICF), and academic performance was measured through Match-to-Sample (MTS) tasks in Portuguese. Spearman's correlation analysis revealed a moderate positive association between adaptive functioning and performance in Portuguese ($r_s = 0.546$; $p = 0.001$), with an effect size of $r^2 = 0.30$, indicating that approximately 30% of the variability in performance can be explained by functional skills. Additionally, odds ratio analysis showed that individuals with higher levels of adaptive functioning were approximately 5.3 times more likely to demonstrate adequate performance in Portuguese ($OR = 5.28$; 95% $CI = 1.19-23.31$; $p = 0.024$). The findings suggest that adaptive functioning is a relevant predictor of literacy-related skills in individuals with Down syndrome. The results reinforce the importance of parental guidance and behavioral interventions aimed at developing adaptive skills, contributing to the literacy process. Interventions focused on functional and behavioral domains may support educational planning and promote more favorable developmental outcomes in this population.

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Received: April 18, 2026; **Accepted:** April 22, 2026; **Published:** April 30, 2026

Keywords: Down Syndrome, Adaptive Functioning, Literacy, Academic Performance, Neurodevelopment

Introduction

Down Syndrome (DS), also known as trisomy 21 (T21), is the most common chromosomal anomaly associated with intellectual disability, resulting from the presence of a complete or partial extra copy of chromosome 21. This genetic alteration leads to significant changes in global development and adaptive functioning and is considered the leading genetic cause of intellectual disability [1]. Its prevalence is estimated at approximately 1 in every 700 to 800 live births, with maternal age as an important risk factor, and it has a broad impact on cognitive, motor, linguistic, and socioemotional domains [2].

From a neurobiological perspective, robust evidence indicates that DS is associated with structural and functional alterations in the central nervous system, including reduced overall brain volume and impairments in regions such as the hippocampus, cerebellum, and frontal and temporal lobes [2]. These alterations largely result from the overexpression of genes located on chromosome 21, affecting fundamental processes such as neurogenesis, synaptic plasticity, and cortical organization [1]. These structural and molecular changes contribute to a characteristic neurocognitive profile.

In the neuropsychological domain, systematic reviews and meta-analyses indicate that individuals with DS present significant impairments in executive functions, particularly working memory, inhibitory control, and cognitive flexibility, with large effect sizes when compared to typically developing groups [3]. In addition, a specific cognitive profile is observed, characterized by greater impairment in short-term verbal memory compared to visuospatial memory, as well as difficulties in expressive language, phonology, and syntax [1,4].

In the motor domain, developmental delays and impairments in postural control, balance, and coordination are frequently reported and are associated with factors such as hypotonia, ligamentous laxity, and proprioceptive alterations [5]. These deficits directly impact autonomy and participation in activities of daily living, contributing to broader functional limitations. In parallel, socioemotional aspects are also relevant, with evidence of difficulties in emotional regulation, increased vulnerability to anxiety, and the presence of maladaptive behaviors in part of this population [6].

The understanding of these manifestations can be expanded through the International Classification of Functioning, Disability and Health (ICF), which proposes a biopsychosocial model integrating body functions and structures, activities,

participation, and contextual factors. This model allows for a more comprehensive analysis of human functioning, overcoming approaches focused exclusively on diagnosis and enabling the identification of functional variables relevant to development.

In the educational context, individuals with DS often present difficulties in the literacy process, particularly related to phonological awareness, verbal memory, and expressive language, which are directly associated with reading and writing performance [4,7]. Evidence suggests that specific linguistic and cognitive skills play a central role in academic development, highlighting the need for adapted and evidence-based pedagogical approaches.

Among the methods used to assess academic performance, task-based paradigms such as Match-to-Sample (MTS) stand out, as they allow the measurement of reading, writing, and mathematical repertoires through conditional relations between stimuli. This model has proven to be sensitive for assessing learning in populations with atypical development, enabling robust quantitative analyses and longitudinal monitoring of performance [7].

Given this context, the present study aimed to investigate the relationship between adaptive functioning, measured through the International Classification of Functioning (ICF), and academic performance in Portuguese, assessed through tasks based on the Match-to-Sample paradigm, in children and adolescents with trisomy 21. It is hypothesized that higher levels of adaptive functioning are associated with better performance in literacy-related skills, contributing to the identification of relevant predictors in the educational development of this population.

Methods

The present study is characterized as a documentary, quantitative research based on the analysis of secondary data extracted from records of a civil society organization (CSO) located in the Brooklin district, in the city of São Paulo. The study was conducted in accordance with ethical principles established by Resolution No. 466/2012 and Resolution No. 510/2016 of the National Health Council, with institutional authorization for data use.

The sample consisted of 33 participants diagnosed with Down syndrome, aged between 9 and 17 years ($M = 14$; $SD = 2.6$), who were regularly enrolled in the institution's educational and cognitive stimulation programs.

Adaptive functioning was assessed using the International Classification of Functioning, Disability and Health (ICF), considering the domains of Activities and Participation. Each item was scored on an ordinal scale ranging from 0 to 4, according to the level of difficulty observed: 4 = no difficulty; 3 = mild difficulty (performs independently); 2 = moderate difficulty (requires verbal guidance); 1 = severe difficulty (requires direct assistance or constant supervision); 0 = complete difficulty (unable to perform the activity). The total score was used as a global indicator of functioning, with lower scores indicating poorer adaptive performance.

Academic performance in Portuguese was measured using tasks based on the Match-to-Sample (MTS) paradigm, widely used to assess academic repertoires in populations with atypical development. The instrument includes conditional relations between stimuli involving matching between spoken words, written words, and pictorial representations. Total scores range

from 0 to 18, with higher scores indicating greater proficiency in reading and writing skills.

Statistical analyses were performed using the Statistical Package for the Social Sciences (SPSS). Initially, Spearman's correlation analysis (r_s) was conducted, given the non-parametric nature of the data, to examine the association between adaptive functioning and academic performance.

Additionally, odds ratio (OR) was calculated as a measure of association between levels of functioning and performance in Portuguese. For this purpose, variables were dichotomized: adaptive functioning was categorized into higher and lower levels based on the sample median, while academic performance was classified as adequate or inadequate according to a cutoff point defined from the distribution of MTS scores. The odds ratio was then estimated by comparing the probabilities of adequate performance across different levels of functioning, with corresponding 95% confidence intervals reported.

Results

Spearman's correlation analysis revealed a moderate positive association between adaptive functioning and academic performance in Portuguese ($r_s = 0.546$; $p = 0.001$), indicating that higher levels of functioning are associated with better performance in reading and writing tasks. The effect size ($r^2 = 0.30$) suggests that approximately 30% of the variability in academic performance can be explained by adaptive functioning.

Additionally, no significant correlation was found between age and performance in Portuguese ($r_s = 0.067$; $p = 0.712$), indicating no association between these variables, even considering the age variability within the sample (8 to 17 years). This finding suggests that academic performance is not directly related to chronological age in this group, reinforcing the relevance of functional variables as more sensitive predictors.

Odds ratio analysis showed that participants with higher levels of adaptive functioning had a greater likelihood of achieving adequate performance in Portuguese compared to those with lower levels of functioning. Specifically, individuals with better adaptive functioning were approximately 5.28 times more likely to demonstrate adequate performance ($OR = 5.28$; 95% $CI = 1.19-23.31$; $p = 0.024$).

These findings indicate that adaptive functioning is a relevant predictor of academic performance in individuals with Down syndrome, regardless of chronological age, reinforcing the relationship between functional abilities and the acquisition of academic skills.

Table 1: Sample Characteristics

	Age	ICF	Reading and Writing
Mean	13	2	13
Maximum	17	3	18
Minimum	8	1	2
SD	2.8	0.49	3.9

Discussion

The findings of the present study indicate that adaptive functioning is a significant predictor of reading and writing performance in individuals with Down syndrome, consistent with previous literature describing the interdependence between cognitive,

linguistic, and adaptive abilities in this population [1,2]. Neuroanatomical and functional alterations associated with trisomy 21, particularly in regions such as the hippocampus and prefrontal cortex, directly affect processes essential for learning, including memory, attention, and executive functions, thereby influencing academic performance [1,3].

In the domain of literacy, evidence suggests that individuals with Down syndrome exhibit heterogeneous developmental trajectories, strongly influenced by linguistic abilities and the learning environment [4,8]. The moderate association observed in this study between adaptive functioning and performance in Portuguese supports the hypothesis that academic skill acquisition is not solely dependent on formal cognitive abilities, but also on the individual's functional repertoire, including communication, autonomy, and participation in social contexts [7].

Executive function deficits, frequently reported in individuals with Down syndrome, may compromise behavioral organization, sustained attention, and inhibitory control, which are essential for literacy development [3]. In addition, difficulties in emotional regulation may negatively affect task persistence and engagement in academic activities, indirectly impacting school performance [6].

In this context, the family environment, particularly parental education, plays a central role as a mediator of adaptive development. Parent-focused interventions have been associated with improvements in language development and the expansion of functional repertoires in children with Down syndrome, facilitating the generalization of skills to naturalistic contexts [8]. Active family involvement contributes to the establishment of routines, increased linguistic stimulation, and enhanced learning opportunities, which are associated with better literacy outcomes.

Furthermore, motor development and postural control, often impaired in this population, are also related to overall functionality and participation in school activities, indirectly influencing academic performance [5,9]. These findings reinforce the need for a multidimensional approach that integrates cognitive, motor, emotional, and environmental factors.

Overall, the results suggest that adaptive functioning not only accompanies but may also modulate academic performance in individuals with Down syndrome. Within this framework, parental education emerges as a strategic component capable of enhancing intervention outcomes and promoting functional gains that directly impact literacy development.

Conclusion

The findings of the present study indicate that adaptive functioning is a relevant predictor of reading and writing performance in individuals with Down syndrome, regardless of chronological age, highlighting the importance of functional variables in the learning process. The observed association suggests that interventions

aimed at promoting adaptive skills, particularly when combined with evidence-based strategies such as Match-to-Sample tasks, may contribute to the acquisition of academic repertoires.

In this context, parental education plays a central role in expanding learning opportunities in daily life, facilitating the generalization and maintenance of acquired skills. However, the findings should be interpreted in light of the study's limitations, including the documentary design based on secondary data, the absence of a control group, the small sample size, and the lack of potentially relevant variables such as socioeconomic status, environmental stimulation, and level of cognitive impairment, which limit causal inference and the generalizability of the results.

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