

Impact of Sleep Quality on Academic Performance in Children With and Without Learning Difficulties

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This study investigated the differences between children with and without learning difficulties (LD) regarding academic performance (AP) and sleep quality (SLQ). A total of 1,501 children were evaluated, including 810 with LD and 691 without LD. The results indicated that children with LD scored significantly lower in AP and had poorer sleep quality, with greater variability in SLQ patterns. Correlation analysis revealed a significant negative association between sleep quality and academic performance ($r = -0.646$; $p < 0.01$), indicating that poorer sleep quality is related to lower academic performance. These findings underscore the importance of interventions focused on promoting sleep hygiene and consistent routines to mitigate the negative impacts of learning difficulties. Study limitations include the absence of mediating variables, such as screen time and mental health, suggesting the need for future research exploring longitudinal interventions and associated factors.

Keywords: children, learning difficulties, sleep quality, academic performance

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Introduction

Learning difficulties (LD) pose a significant challenge in the educational context, impacting many students' ability to reach their academic potential. Characterized by specific impairments in skills such as reading, writing, or mathematical calculation, these difficulties are not attributed to intellectual or sensory deficits but rather to factors associated with cognitive processing (Cardoso et al., 2024). Recent studies suggest that, in addition to factors directly related to school performance, extracurricular aspects, such as sleep quality, may play a critical role in the academic success of children with learning difficulties (Jalali et al., 2020; Zarazaga-Peláez et al., 2024; Sidek, Kamal, & Rahman, 2024).

Sleep is widely recognized as an essential biological process for child development, influencing cognitive functions such as attention, memory, and information consolidation (Ramar et al., 2021). In children, inadequate sleep quality can negatively impact learning and behavior, impairing their ability to acquire and apply knowledge in educational settings (Hayes & Bainton, 2020). However, despite growing scientific interest in the relationship between sleep and academic performance, there is a gap in the literature regarding this association in specific populations, such as children with learning difficulties (Musshafen et al., 2021; Machado, Ricardo, Wendt, & Wehrmeister, 2022; Patel et al., 2022; Bacaro, Carpentier, & Crocetti, 2023).

In this context, understanding how sleep quality affects academic performance in children with LD is crucial for identifying interventions that could mitigate the challenges faced by these students. Preliminary studies suggest that children with LD may exhibit dysregulated sleep patterns, which, in turn, exacerbate their existing academic limitations (Gallego-Gómez et al., 2021; Bacaro et al., 2023). However, few studies quantitatively explore this relationship, especially in representative samples that consider systematic differences between children with and without learning difficulties (Al-Qadri et al., 2021; Lone, Khan, AlWadani, & Almaqawi, 2024).

Thus, this study aims to investigate the relationship between sleep quality (SLQ) and academic performance (AP) in children with and without learning difficulties. Specifically, it seeks to: (1) compare sleep quality and academic performance scores between the two groups, and (2) examine whether sleep quality is associated with differences in academic performance. The central hypothesis is that children with learning difficulties exhibit poorer sleep quality and, consequently, lower academic performance, reflecting the impact of sleep-related factors within the educational context.

Materials and Methods

Participants

The study included 2,803 students, aged between 8 and 10 (± 9.65) years old, in the third, fourth, and fifth years of a Brazilian public elementary school in Joinville, Santa Catarina, Brazil. The criteria for selecting children included.

The inclusion and exclusion criteria of children's selection were:

- Present indications of proficient school performance proven by legal documents issued by the pedagogical team of the school in which they were enrolled;
- Have an estimated IQ (Wechsler Intelligence Scale for Children—WISC-IV) above 80;
- Do not use psychoactive medication;
- Do not show expressive symptoms of inattention, hyperactivity, or impulsivity through the SNAP-IV evaluation;
- Do not have visual or auditory disorders, heart disease, orthopedic disorders, or behavioral disorders (according to medical evaluation throughout the study).

After applying the inclusion and exclusion criteria, a total of 1,501 children were selected. The participants were divided into two groups based on their school history, which was assessed using an inventory completed by the pedagogical staff of the schools. This inventory provided detailed information that allowed the identification of 810 children (With LD) who exhibited learning difficulties and 691 children (Without LD) who did not present such difficulties. The use of this inventory ensured that the categorization was supported by the observations and pedagogical records of the educational institutions. It is noteworthy that all children attended the afternoon school shift.

Procedures

Initially, participants underwent an academic performance (AP) assessment through a test comprising 30 questions, including 15 focused on Portuguese language skills and 15 on mathematical abilities. The questions were selected from an item bank of the Basic Education Evaluation System (SAEB), ensuring the pedagogical relevance and rigor of the instrument. To maintain randomness, each child received a unique, randomized test, ensuring no evaluation was identical to another participant's.

The assessment was administered in the participants' own classrooms, in a well-lit and organized environment designed to minimize external interference. The evaluation team consisted of two trained assessors, members of the study, who adhered to a standardized protocol to ensure process uniformity. Notably, the assessors had no prior knowledge of which children had or did not have learning difficulties, ensuring impartiality and objectivity during the assessment process.

Twenty-four hours after the AP assessment, participants completed the Sleep Quality Screening Scale (SLQ) to evaluate sleep quality. This scale was designed to identify patterns and behaviors related to sleep that could affect the children's well-being and performance. Comprising 22 items, the scale assessed aspects related to pre-sleep behavior, sleep itself, waking, and daytime routines. Each item was rated using a five-point Likert scale, where "1 point" corresponded to "never" (the behavior never occurs), "2 points" to "rarely" (occurs very infrequently), "3 points" to "sometimes" (occurs occasionally), "4 points" to "often" (occurs frequently), and "5 points" to "always" (occurs constantly). The total score was calculated by summing the points, with higher scores indicating greater likelihood of sleep quality disturbances.

The scale was administered collectively in the children's classrooms, in a well-lit and organized environment to minimize distractions. Before starting, a clear and brief explanation was provided, highlighting the purpose of the instrument and the response format, with simple examples to facilitate understanding. Children were instructed to use only a pencil and the assessment sheet during completion, and for those whose feet did not reach the floor, appropriate supports were provided to ensure comfort and enhance focus.

Each classroom had four trained assessors from the research team, whose role was to clarify any potential questions and ensure standardized completion of the scale. As with the AP assessment, the assessors had no prior knowledge of which children had or did not have learning difficulties, safeguarding impartiality in data collection.

Statistical Analysis

For the statistical analysis, data on academic performance (AP) and sleep quality (SLQ) were compared between groups of children with learning difficulties (With LD) and without learning difficulties (Without LD). AP and SLQ scores were treated as continuous variables and analyzed using descriptive statistics, including mean, standard deviation, standard error of the mean, coefficient of variation, and confidence intervals. To assess

differences between the groups, an independent samples t-test was employed, ensuring the identification of statistically significant differences in the variables of interest.

Additionally, the F-test for homogeneity of variances was applied to verify variability between the groups. A Pearson correlation analysis was also conducted to explore potential relationships between sleep quality and academic performance, allowing for the identification of the potential impact of sleep quality on academic performance scores. All statistical analyses were performed using a significance level of $p < 0.05$ and reported with their respective effect sizes, such as the coefficient of determination (R^2), to enhance the robustness of result interpretation.

The procedures were conducted using the GraphPad Prism 10.4 statistical software, ensuring reliability and reproducibility of the analyses performed.

Results

The data presented in Figure 1a compare academic performance (AP) scores between individuals without learning difficulties (Without LD) and those with learning difficulties (With LD). In the Without LD group, scores range from a minimum of 15.00 to a maximum of 27.00, with a mean of 18.84. This group exhibits a standard deviation of 3.077 and a standard error of the mean of 0.117, indicating that the values are relatively concentrated around the mean. The coefficient of variation is 16.33%, confirming moderate variability in the scores of this group.

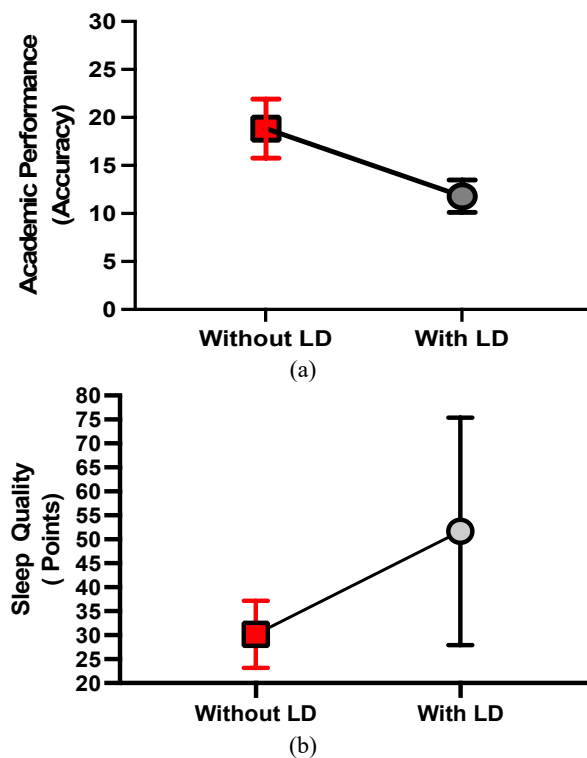


Figure 1. Comparison between groups of children without learning difficulties (Without LD) and with learning difficulties (With LD) regarding academic performance (AP) and sleep quality (SLQ). (a) displays academic performance (AP), expressed in terms of accuracy. It is observed that the Without LD group exhibits significantly higher mean scores, while the With LD group shows lower scores, indicating a negative impact of learning difficulties on academic performance. Data are expressed as mean and standard deviation. (b) depicts sleep quality (SLQ), expressed in points, where higher values indicate poorer sleep quality. The With LD group shows higher scores, reflecting inferior sleep quality compared to the Without LD group. Data are expressed as mean and standard deviation.

In contrast, in the With LD group, academic performance (AP) scores range from 8.00 to 14.00, with a considerably lower mean of 11.80. This group shows less data dispersion, with a standard deviation of 1.684 and a standard error of the mean of 0.059, reflecting greater precision in estimating the mean. The coefficient of variation is 14.28%, suggesting slightly more homogeneous values compared to the Without LD group. These results, analyzed through the t-test, were found to be statistically significant ($t = 56.06$; $df = 1,499$; $p < 0.01$), indicating that children with learning difficulties have significantly lower academic performance scores on average.

When evaluated for sleep quality (SLQ) (Figure 1b), the Without LD group scores ranged from 22.00 to 81.00, with a mean of 30.18. This group demonstrated lower data dispersion, evidenced by a standard deviation of 6.981. The standard error of the mean was 0.2656, indicating a precise estimate of the mean. Furthermore, the coefficient of variation was 23.13%, reinforcing that scores were relatively concentrated around the mean, suggesting more uniform and, on average, better sleep quality in this group.

In contrast, in the With LD group, SLQ scores ranged from 33.00 to 110.0, with a significantly higher mean of 51.66, reflecting poorer sleep quality. This group exhibited greater data dispersion, with a standard deviation of 23.73, and the standard error of the mean was 0.8337, indicating greater uncertainty in the mean estimate due to more pronounced variability. The coefficient of variation of 45.94% confirmed greater heterogeneity in the scores for this group.

In summary, the results indicate that individuals with learning difficulties tend to exhibit poorer sleep quality (higher SLQ scores) and greater variability in their sleep patterns compared to those without learning difficulties. These findings suggest that learning difficulties may be associated with more pronounced alterations in sleep quality, which could, in turn, negatively impact academic performance and overall health.

The results of the independent samples t-test compared SLQ scores between individuals with learning difficulties (With LD) and without learning difficulties (Without LD). The test revealed a statistically significant difference between the groups ($t = 22.96$; $df = 1,499$; $p < 0.001$), with mean scores of 51.66 for the With LD group and 30.18 for the Without LD group. The mean difference between the two groups was 21.48 (± 0.9355), with a 95% confidence interval ranging from 19.65 to 23.32. This difference explained 26.02% of the total variance in scores ($R^2 = 0.2602$), indicating that the impact of learning conditions is considerable. Additionally, the F-test for variance comparison showed significant differences in variances ($F = 11.55$; $p < 0.01$), confirming greater score dispersion in the With LD group. These findings indicate that individuals with learning difficulties exhibit significantly poorer sleep quality (higher scores) and greater variability in their sleep patterns compared to those without learning difficulties.

To enhance the reliability of the results and deepen the analysis, a potential relationship between sleep habits and academic performance (AP) was investigated. This approach allowed an examination of how characteristics related to sleep quality might influence academic performance levels in individuals with and without learning difficulties. The analysis was based on well-established metrics, such as Pearson's correlation ($r = -0.646$; $p < 0.01$), which indicates that as SLQ scores increase (i.e., sleep quality worsens), academic performance tends to decrease (Figure 2).

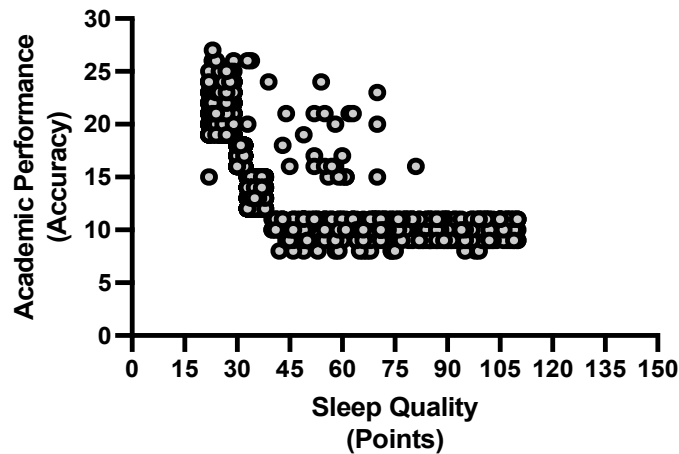


Figure 2. Relationship between sleep quality and academic performance in schoolchildren. The figure presents a scatter plot illustrating the relationship between sleep quality (SLQ), expressed in points (X-axis), and academic performance (AP), expressed in accuracy (Y-axis). Each point represents an individual included in the analysis. A negative relationship between the variables is observed, where higher sleep quality scores (indicating poorer sleep quality) are associated with lower academic performance scores. This pattern reflects the adverse impact of poor sleep quality on academic performance, supporting the previously presented statistical results.

Discussion

The results of this study highlight significant differences between children with and without learning difficulties (LD) in both academic performance (AP) and sleep quality (SLQ). These findings align with existing literature suggesting a bidirectional relationship between learning difficulties and factors related to sleep and academic performance (Jalali et al., 2020; Zarazaga-Peláez et al., 2024; Sidek et al., 2024).

The data reinforce the idea that learning difficulties are not merely transient individual variations but a significant and measurable factor that broadly impacts school performance (Kuriakose & Amaresha, 2024). The magnitude of the difference between groups, coupled with the lower standard deviation in the With LD group, demonstrates that learning difficulties impose clear and recurring limitations on academic performance (Lone et al., 2024).

Moreover, the lower variability in mean scores in the With LD group (coefficient of variation of 14.28% compared to 16.33% in the Without LD group) emphasizes the representativeness of the data and the homogeneity of the impact of learning difficulties within this group. This pattern reveals that children with learning difficulties share common challenges affecting their school performance relatively uniformly, underscoring the priority of identifying and supporting these students in educational settings (Cardoso et al., 2021; Cardoso et al., 2024; Baiti, Devri, & Arga, 2024).

The SLQ scores confirmed that children with learning difficulties (With LD) exhibited significantly poorer sleep quality (51.66 ± 23.73) compared to children without difficulties (30.18 ± 6.981), with a mean difference of 21.48 points ($t = 22.96$; $p < 0.001$). These data demonstrate that individuals with learning difficulties experience inferior sleep quality compared to their peers without difficulties, reinforcing the idea that sleep may be a critical factor in the academic limitations observed in this group (Jalali et al., 2020; Tomaso, Johnson, & Nelson, 2021; Sidek et al., 2024).

The relationship between learning difficulties and sleep quality can be understood in light of the cognitive and emotional demands imposed by the school environment. Children with learning difficulties often need to

dedicate more time and effort to school tasks, which can lead to increased cognitive activation at night, making it harder to transition to sleep (Okano et al., 2019; Grigorenko et al., 2020; F. Aydin & A. Aydin, 2024). Additionally, academic demands can generate persistent worries or frustrations that contribute to difficulty relaxing before bed (Pascoe, Hetrick, & Parker, 2019). Thus, the inadequate sleep observed in this group may be a direct consequence of the greater challenge these children face in meeting school demands (Lolles et al., 2022; Yeo et al., 2023).

On the other hand, the Without LD group showed greater consistency in SLQ scores, evidenced by a lower standard deviation (6.981) and coefficient of variation (23.13%). This suggests that children without LD find it easier to establish and maintain consistent sleep routines, possibly because their academic demands are more aligned with their cognitive capacities, reducing the level of effort required and promoting full recovery during sleep (Sidek et al., 2024; Sun et al., 2024).

The association between sleep quality and academic performance is supported by the significant negative correlation observed in the study ($r = -0.646$; $p < 0.01$). This indicates that poorer sleep quality is associated with lower academic performance, regardless of other factors. Children with LD, who experience greater difficulty achieving good sleep quality, may thus face cumulative impacts on their ability to concentrate, remember, and solve problems. These cognitive processes are directly influenced by sleep and are essential for learning (Lolles et al., 2022; Yeo et al., 2023; Sidek et al., 2024; Sun et al., 2024).

This pattern can be explained by the fundamental role of sleep in memory consolidation and the strengthening of neural connections related to learning (Brodth, Inostroza, Niethard, & Born, 2023). During sleep, information acquired throughout the day is integrated, facilitating retention and application of knowledge in future tasks (Paller, Creery, & Schechtman, 2021). Children with poorer sleep quality may experience impaired integration, putting them at a disadvantage compared to children without learning difficulties (Cousins et al., 2021; Liu et al., 2024).

The results of this study emphasize the importance of strategies that promote sleep regularity in children with LD (Chen et al., 2023). Implementing consistent routines, set bedtimes, and wake times and creating sleep-friendly environments could be beneficial (Trindade & Ramos, 2020). These actions may not only improve sleep quality but also mitigate its negative impacts on academic performance (Turnbull et al., 2022).

Finally, the mean difference of 21.48 points in SLQ between groups highlights the relevance of including sleep quality assessment in studies and interventions targeting children with learning difficulties (Tangwijitsakul et al., 2024). Improvements in sleep quality could significantly impact their academic performance, enhancing pedagogical efforts and promoting more balanced development (Adelantado-Renau et al., 2019).

Conclusion

The results obtained reinforce the importance of interventions aimed at improving sleep quality, particularly in children with learning difficulties. Strategies such as promoting sleep hygiene, establishing consistent routines, and managing underlying medical conditions, such as sleep apnea, can positively impact academic performance.

Additionally, the need for integrated approaches that consider both academic and physiological factors is highlighted. School programs could include education on healthy sleep, while clinical interventions might monitor and treat sleep disorders. These combined actions could mitigate the adverse impacts observed in this study.

Although the results provide robust evidence, certain limitations should be considered. For instance, the study did not investigate mediating factors such as screen time, family support, and mental health, which could influence both sleep quality and academic performance. Future studies should explore these variables and evaluate longitudinal interventions to determine the effectiveness of targeted strategies.

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