

Investigating the Effectiveness of the RhythmoGame Method in Reducing Spelling Learning Disorders among First-Cycle Primary School Students

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ABSTRACT

The present study aimed to investigate the effectiveness of the RhythmoGame method in reducing spelling learning disorders among first-cycle primary school students. This study employed a quasi-experimental pretest-posttest design with an intervention group and a control group. The statistical population consisted of primary school students in Sabzevar, Iran, during the 2024–2025 academic year who had been identified as having spelling learning disorder. Thirty eligible students were assigned to the RhythmoGame intervention group and the control group, with 15 students in each group. Data were collected using the Wechsler Intelligence Scale for Children–Fourth Edition, the Colorado Learning Difficulties Questionnaire, and a researcher-developed spelling assessment measuring visual memory, visual sequential memory, auditory memory, auditory sensitivity, attention, educational spelling difficulties, and dysgraphia-related difficulties. The intervention group participated in the RhythmoGame program for two months, with two sessions per week lasting approximately 45–60 minutes. The program included rhythmic games, music, coordinated movement, auditory attention, sequencing, motor planning, response inhibition, and group interaction. The control group continued its usual educational activities. Data were analyzed using analysis of covariance after examining the relevant statistical assumptions. Analysis of covariance showed a statistically significant effect of group membership on posttest spelling learning disorder scores after controlling for pretest scores, $F(1, 27) = 131.13$, $p < .001$, partial $\eta^2 = .829$. The pretest covariate was also significant, $F(1, 27) = 13.68$, $p = .001$, partial $\eta^2 = .336$. The adjusted posttest results indicated that students in the RhythmoGame group had significantly lower spelling learning disorder scores than those in the control group. The findings indicate that RhythmoGame can be an effective complementary educational intervention for reducing spelling learning disorders in young primary school students, possibly through simultaneous engagement of auditory processing, attention, sequencing, memory, motor coordination, and response control.

Keywords: RhythmoGame, Spelling Learning Disorder, Specific Learning Disorder, Primary School Students, Rhythm-Based Intervention, Game-Based Learning

1. Introduction

Learning to read and write is one of the most fundamental developmental and educational achievements of the early school years. Successful acquisition of these skills provides the foundation for later academic achievement, classroom participation, communication, and independent learning. Among written-language skills, spelling occupies a particularly important position because it requires children to transform phonological, orthographic, visual, auditory, linguistic, attentional, and motor information into accurate written forms. Spelling is therefore more than the simple memorization of words; rather, it is a complex cognitive-linguistic activity involving the analysis of speech sounds, retention of orthographic representations, sequencing of letters, retrieval from memory, sustained attention, and coordinated written production. When one or more of these processes do not develop adequately, children may exhibit persistent difficulties in writing words correctly despite receiving conventional classroom instruction. Such difficulties can substantially affect educational performance during the first years of primary school, when written-language competencies are rapidly developing and increasingly become prerequisites for successful participation in other academic activities (Pasqualotto & Venuti, 2024; Sigmund et al., 2024).

Spelling learning disorder is generally characterized by persistent and developmentally inappropriate problems in the accurate representation of spoken words in written form. Affected students may omit, substitute, reverse, add, or incorrectly sequence letters; confuse phonologically or visually similar units; fail to maintain accurate orthographic representations; or repeatedly make spelling errors despite instruction and practice. In educational settings, these errors may initially appear similar to ordinary mistakes made by beginning writers, but their persistence, frequency, and resistance to conventional instruction distinguish them from transient developmental errors. Research on the classification and explanation of spelling errors indicates that spelling problems can arise from multiple underlying mechanisms and therefore should not be treated as a unitary deficit. Analysis of spelling errors among elementary school students has shown that different patterns of error may reflect difficulties in phonological processing, visual recognition, auditory discrimination, orthographic encoding, sequencing, and linguistic processing (Zareifard & Tadayon, 2024). Accordingly, effective intervention should be based

on an understanding of the multiple perceptual, cognitive, linguistic, and motor processes involved in spelling rather than relying solely on repeated dictation exercises.

Contemporary research further suggests that spelling performance is influenced by both domain-specific language abilities and broader cognitive capacities. Longitudinal evidence indicates that early cognitive abilities can predict later spelling and reading performance, highlighting the importance of processes such as phonological awareness, working memory, rapid retrieval, attention, and other cognitive functions in the acquisition of written language (Sigmund et al., 2024). Similarly, research examining predictors of reading and spelling difficulties has demonstrated that both specific linguistic abilities and general cognitive skills contribute to individual differences in literacy development (Pasqualotto & Venuti, 2024). These findings are important because they imply that children with spelling learning disorder may require interventions extending beyond conventional word repetition. If spelling difficulties are partly associated with weaknesses in attention, memory, sequencing, auditory processing, visual processing, and executive control, intervention methods that simultaneously stimulate several of these capacities may be particularly useful.

The cognitive profiles of individuals with literacy disorders also demonstrate considerable heterogeneity. Dyslexia and related learning difficulties cannot be adequately understood as manifestations of a single generalized intellectual weakness. Investigations of intelligence profiles in individuals with dyslexia suggest differentiated patterns of cognitive strengths and vulnerabilities, reinforcing the view that learning disorders involve specific cognitive-processing configurations rather than global intellectual impairment (Radtko et al., 2025). This distinction has major educational implications. Students with spelling disorders may have adequate general intelligence while experiencing circumscribed difficulties in the cognitive processes required for written language. Consequently, intervention should focus on the functional mechanisms associated with spelling performance and should provide opportunities for children to use intact abilities to compensate for or strengthen weaker processes. Such an approach is particularly relevant during early primary education, because intervention at this stage can potentially prevent repeated academic failure and the consolidation of maladaptive learning patterns.

One of the extensively studied mechanisms associated with spelling problems is phonological processing. Accurate

spelling requires the child to perceive the phonological structure of spoken words, segment words into smaller sound units, associate phonemes with corresponding graphemes, and maintain these sequences while writing. Interventions that directly strengthen phonological awareness have therefore been used to address spelling difficulties. Comparative research has indicated that direct instruction, phonological-awareness training, and combinations of these approaches can reduce spelling problems among elementary school students (Karimi et al., 2011). More recent work has similarly examined combined direct instruction and phonological-awareness programs for reducing spelling errors among students diagnosed with spelling learning disorder, further supporting the importance of explicitly targeting the sound structure of language and its relationship with written symbols (Ghanizadeh Bidokhti, 2023). Although such interventions have demonstrated value, spelling performance is not determined exclusively by phonological competence, and interventions targeting only one pathway may not sufficiently address the multidimensional difficulties experienced by some students.

Multisensory instructional approaches have consequently received increasing attention in the treatment of learning disorders. Multisensory methods are based on the assumption that learning can be facilitated when information is processed simultaneously or sequentially through multiple sensory channels, such as visual, auditory, tactile, and kinesthetic modalities. Instead of asking a child merely to look at and reproduce a written word, multisensory interventions can require the learner to see, hear, say, trace, move, and reproduce information in an integrated manner. Evidence suggests that Rosner's multisensory teaching method can reduce spelling-writing difficulties among elementary school students (Oladghobad et al., 2021). Similarly, the Fernald multisensory approach has been reported to improve dictation and reading difficulties in students with learning disabilities (Pourkamali et al., 2022). These findings indicate that interventions incorporating active sensory engagement can potentially strengthen encoding and retrieval processes that are essential for successful spelling.

The emphasis on multisensory engagement is consistent with established remedial perspectives on spelling instruction. Educational approaches to dictation difficulties have long highlighted the importance of identifying the specific nature of the child's errors and providing targeted exercises addressing relevant processes such as visual memory, auditory discrimination, attention, sequencing, and

accurate written reproduction (Tabrizi, 2011). A child who repeatedly confuses visually similar letters, for example, may require a different form of intervention from a child whose errors primarily reflect weak auditory discrimination or inadequate phoneme-grapheme correspondence. Therefore, remedial spelling instruction is likely to be more effective when it moves beyond repetitive correction and involves structured exercises that actively engage the underlying processes responsible for the child's pattern of errors.

Game-based instructional methods constitute another promising approach to improving spelling and related academic skills. Games can transform repetitive learning tasks into structured, motivating, and interactive experiences. Educational games can provide immediate feedback, repeated practice, behavioral engagement, focused attention, and opportunities for children to learn through action rather than passive reception. In the context of spelling intervention, word-play training has been shown to reduce spelling problems among first-grade elementary school students (Ghaffari et al., 2020). Such findings are particularly relevant because young children may respond more positively to interventions presented in playful forms than to repetitive corrective exercises that resemble their ordinary classroom tasks. Game-based learning may therefore increase participation and persistence while simultaneously allowing therapeutic or educational objectives to be embedded within enjoyable activities.

The potential benefits of game-based methods are not limited to language learning. Research increasingly indicates that games involving movement, rhythm, rule following, and coordinated action can stimulate cognitive as well as motor functions. Practice of fundamental motor skills through game-centered approaches has been associated with improvements in both motor and cognitive performance among children with attention-deficit/hyperactivity disorder (Najafi et al., 2024). This finding supports the broader proposition that structured physical and game-based activities may influence processes such as attention, inhibitory control, working memory, sequencing, and cognitive flexibility. These processes are also relevant to spelling because the child must maintain attention to verbal input, inhibit competing responses, remember the sequence of sounds and letters, and accurately execute the required written response. Thus, movement-based educational games may have potential value for children whose spelling difficulties involve weaknesses extending beyond purely linguistic processing.

Perceptual-motor functioning represents another area of importance in the study of learning disabilities. Writing is inherently a perceptual-motor task, requiring coordination between visual perception, spatial processing, motor planning, and fine-motor execution. Research has shown that training perceptual-motor skills can improve reading, writing, and mathematics performance among students with specific learning disorders (Naderi et al., 2018). Visual-motor integration is particularly significant because written production requires the translation of visually and linguistically represented information into coordinated motor output. Studies focusing on children with developmental coordination difficulties have also emphasized the importance of visual-motor integration as a neuropsychological function associated with children's effective performance in tasks requiring coordinated perception and action (Niknasab et al., 2023). These observations provide a rationale for interventions that incorporate coordinated rhythmic movement alongside perceptual and cognitive activities.

Rhythmic activity is particularly relevant because rhythm inherently requires temporal organization, sequencing, attention, prediction, auditory discrimination, motor coordination, and synchronization. When a child listens to a rhythm and reproduces it by clapping, stepping, tapping, or moving, the activity involves receiving auditory information, retaining a temporal pattern, organizing an appropriate response, and executing the response in the correct sequence. These processes overlap considerably with cognitive demands involved in spelling. In spelling, children must listen to spoken linguistic information, distinguish relevant auditory units, maintain their order in working memory, map them onto orthographic forms, and produce an ordered sequence of written symbols. Consequently, rhythmic training may provide an indirect but functionally relevant means of strengthening some of the cognitive-perceptual capacities underlying spelling performance.

Evidence from rhythmic and movement-based interventions supports their potential to influence developmental outcomes. Rhythmic and group games have been found to improve gross motor skills and social interaction in children with autism, suggesting that rhythm-based activities can simultaneously activate motor organization, interpersonal responsiveness, imitation, attention, and group coordination (Daneshyar et al., 2019). Although children with autism and students with spelling learning disorder constitute different populations, the mechanisms engaged by rhythmic activities may have

broader developmental relevance. Activities requiring imitation of rhythmic sequences, coordinated movement, response to auditory cues, starting and stopping on command, and turn-taking can provide repeated practice in attention regulation, motor planning, sequencing, and behavioral inhibition.

Rhythmic movement has also been investigated in relation to academic learning disorders beyond literacy. Educational-sport games combined with rhythmic movements have demonstrated beneficial effects on mathematics skills among students with mathematics learning disorder (Zoghi et al., 2020). Such findings are significant because they indicate that rhythmic and motor activities may contribute to academic performance even when the targeted academic domain is not itself primarily motor. One explanation is that rhythm-based activities exercise domain-general functions such as working memory, sustained attention, temporal processing, sequencing, and executive regulation, which are required across multiple academic tasks. If this interpretation is applicable to spelling, rhythmic games could provide a means of strengthening the cognitive architecture supporting accurate written-language performance while simultaneously maintaining children's motivation and active participation.

Recent developments in game-based rhythm training provide additional support for combining rhythm and play within instructional programs. A rhythm-game approach to piano practice has been developed as a means of increasing motivation and supporting learners through game-based engagement with rhythm and musical practice (Athalia et al., 2024). Although musical skill acquisition differs from spelling remediation, rhythm games illustrate how structured repetition can be embedded within an intrinsically engaging format. The learner is required to attend to temporal cues, detect patterns, respond accurately, coordinate actions with external stimuli, and gradually manage increasing task complexity. These characteristics correspond closely to several objectives of learning-disorder interventions, particularly those aimed at strengthening attention, sequencing, working memory, coordination, and persistence.

Another advantage of game-based interventions is their potential to reduce the negative emotional experiences frequently associated with remedial education. Children with persistent spelling difficulties repeatedly encounter correction, low academic scores, comparison with classmates, and tasks that expose areas of weakness. Over time, conventional remedial activities may be perceived as

extensions of the same academic demands in which the child has repeatedly experienced difficulty. In contrast, rhythmic games offer an experiential format in which skill development occurs through music, movement, interaction, imitation, and play. This can potentially increase willingness to participate and sustain attention during training. The success of flashcard-based training in improving written spelling difficulties also demonstrates that modifying the instructional format and providing structured, repeated exposure to target material can produce meaningful improvements in spelling performance (Abrishamizadeh, 2017). Nevertheless, flashcards primarily emphasize visual exposure and retrieval, whereas rhythmic game approaches potentially integrate auditory, visual, kinesthetic, attentional, temporal, and social components within the same intervention.

The literature therefore suggests that effective intervention for spelling learning disorder may benefit from an integrative framework. Direct and phonological instruction can strengthen explicit sound–symbol relationships (Ghanizadeh Bidokhti, 2023; Karimi et al., 2011), multisensory instruction can facilitate encoding across sensory modalities (Oladghobad et al., 2021; Pourkamali et al., 2022), perceptual-motor training may strengthen cognitive and academic functioning (Naderi et al., 2018), and game-based activities may enhance engagement while exercising attentional and cognitive processes (Ghaffari et al., 2020; Najafi et al., 2024). Rhythm-based interventions potentially bring several of these mechanisms together within a unified activity. Listening to a rhythmic pattern engages auditory attention; reproducing it requires working memory and sequencing; coordinated movement recruits perceptual-motor processes; changing rhythm or stopping on cue requires response inhibition and behavioral flexibility; and group-based games create opportunities for imitation, social responsiveness, and sustained motivation.

Despite these theoretical and empirical indications, comparatively limited attention has been given to the direct application of structured rhythm-game programs for reducing spelling learning disorders among children in the early primary grades. Existing research has more commonly examined direct teaching, phonological awareness, word games, multisensory approaches, flashcards, perceptual-motor programs, or rhythmic interventions in other developmental and academic contexts. At the same time, emerging evidence regarding cognitive predictors of spelling indicates that successful spelling depends on

interacting linguistic and general cognitive systems rather than on a single isolated capacity (Pasqualotto & Venuti, 2024; Sigmund et al., 2024). Moreover, differences in cognitive profiles among individuals with literacy disorders reinforce the need for diversified interventions capable of engaging multiple developmental pathways (Radtke et al., 2025). A structured RhythmoGame intervention may respond to this need by integrating rhythm, auditory processing, coordinated movement, sequencing, attention, inhibition, memory, creativity, and social participation into a child-centered educational program.

This issue is particularly important during the first cycle of primary education. The early grades constitute a sensitive educational period in which children consolidate basic literacy skills that will support subsequent learning across the curriculum. Persistent spelling difficulties during this period may interfere with written expression and may also restrict the child's ability to demonstrate knowledge in other subjects. Early identification and targeted remediation are therefore educationally important. Furthermore, because young children characteristically learn through movement, imitation, repetition, sensory exploration, and play, interventions that are developmentally compatible with these learning characteristics may have advantages over exclusively worksheet-based or verbally mediated approaches. RhythmoGame is consistent with this developmental perspective because it transforms cognitive-perceptual exercises into rhythmic activities involving the child's body, attention, memory, auditory system, and interaction with peers.

Considering the multidimensional nature of spelling learning disorder, the demonstrated relevance of phonological, cognitive, perceptual-motor, and multisensory processes to spelling acquisition, and the growing evidence supporting game-based and rhythmic approaches in child development and learning, evaluating the educational effectiveness of RhythmoGame represents a potentially valuable contribution to the literature. Such research can help determine whether an intervention originally organized around rhythm, movement, and play can produce measurable improvement in an academic difficulty such as spelling and can provide evidence for teachers, learning-disability specialists, counselors, and educational practitioners seeking engaging complementary interventions for young students with persistent spelling problems. Therefore, the aim of the present study was to investigate the effectiveness of the RhythmoGame method in reducing

spelling learning disorders among first-cycle primary school students.

2. Methods and Materials

2.1. Study Design and Participants

The present study employed a quasi-experimental pretest–posttest design with an intervention group and a control group to investigate the effectiveness of the RhythmoGame method in reducing spelling learning disorders among first-cycle primary school students. The independent variable was the instructional method, consisting of two conditions: the RhythmoGame intervention and the control condition, whereas the dependent variable was the severity of spelling learning disorder, assessed through participants' scores on the spelling assessment. To control for possible baseline differences between the two groups and to obtain a more accurate estimate of the intervention effect, pretest scores were considered as a covariate in the statistical analysis. A quasi-experimental design was selected because of the practical constraints associated with conducting intervention studies in educational environments and the difficulty of achieving complete experimental control under ordinary school conditions. The statistical population consisted of primary school students in Sabzevar, Iran, during the 2024–2025 academic year who had been identified as having a spelling learning disorder. Students were screened for eligibility using measures of intellectual functioning, learning difficulties, and spelling performance. Eligible students were allocated to an intervention group receiving the RhythmoGame program and a control group that did not receive the RhythmoGame intervention during the study period. The inclusion process was intended to ensure that the participants' spelling difficulties represented a specific learning problem rather than difficulties attributable primarily to general intellectual impairment. Both groups completed the spelling assessment before the beginning of the intervention and again after completion of the intervention period, thereby allowing changes in spelling-related learning difficulties to be compared while statistically controlling for initial performance.

2.2. Measures

Data were collected using the Wechsler Intelligence Scale for Children–Fourth Edition (WISC-IV), the Colorado Learning Difficulties Questionnaire (CLDQ), and a

researcher-developed spelling assessment. The WISC-IV was used to assess the general intellectual functioning of the participants and to assist in determining whether their academic difficulties were consistent with a specific learning disorder rather than a broader intellectual limitation. Previous psychometric evaluations of the scale have reported Cronbach's alpha reliability coefficients ranging from .65 to .94 across its subtests and split-half reliability coefficients ranging from .76 to .91. Evidence of construct validity has also been reported through correlations between subscale scores and the overall test score, with validity coefficients ranging from .66 to .92 (Sharifi & Rabiei, 2012). The Colorado Learning Difficulties Questionnaire was originally developed by Willcutt et al. (2011) as a screening instrument for identifying children who exhibit learning-related difficulties and was used in the present study as an additional instrument for recognizing students at risk of learning disorders. Its applicability for the identification of learning problems has also been addressed in Persian-language research (Hajloo & Rezaei, 2011). The principal outcome measure was a spelling test developed on the basis of the Persian-language textbooks used in the first, second, and third grades of primary school and prepared in consultation with experienced primary school teachers. The test was designed to evaluate major processes involved in spelling performance, including visual memory, visual sequential memory, visual discrimination, auditory memory, auditory sensitivity, attention and concentration, educationally related spelling errors, and dysgraphia-related difficulties. Its items consisted of words and sentences selected from the Persian curriculum and were constructed to represent common spelling errors associated with these domains. Content validity was evaluated and confirmed by seven teachers specializing in learning difficulties. Test–retest reliability was examined in a sample of 40 students with diagnosed spelling difficulties in Sabzevar. Pearson correlation coefficients between the first and second administrations demonstrated high temporal stability across the assessed dimensions, including visual memory ($r = .920$, $p < .001$), visual sequential memory ($r = .955$, $p < .001$), auditory memory ($r = .879$, $p < .001$), auditory sensitivity ($r = .936$, $p < .001$), attention ($r = .887$, $p < .001$), educational spelling difficulties ($r = .966$, $p < .001$), and dysgraphia-related spelling performance ($r = .935$, $p < .001$). These coefficients indicated that the instrument had satisfactory reliability for assessing changes in spelling-related learning difficulties.

2.3. Interventions

The experimental intervention consisted of the RhythmoGame method, a structured program combining rhythmic games, music, coordinated body movements, auditory stimulation, motor responses, attention exercises, sequencing activities, and group interaction. The intervention was implemented over a period of two months, with two sessions conducted each week, and each session lasted approximately 45 to 60 minutes. The eight-session structured protocol was specifically designed for children aged 6 to 9 years and progressed gradually from elementary rhythm perception and imitation to more complex activities requiring working memory, response inhibition, sequencing, motor planning, creativity, and social participation. During the first session, emphasis was placed on establishing rapport, creating psychological safety within the group, introducing simple group rules, and familiarizing children with the concepts of beat and rhythm. Activities included introducing oneself through rhythmic clapping, reproducing two- and three-beat patterns, walking in synchrony with musical beats, and participating in movement-and-stop games. The second session focused on auditory attention and motor imitation through active listening, responses to specific auditory stimuli, clapping, knee tapping, foot tapping, and games requiring children to perform an action only after hearing a designated sound or instrument. The third session targeted motor coordination and spatial orientation by integrating rhythmic movement with changes in speed, direction, and location; activities included rhythmic walking, gentle jumping, spiral movement, moving through pathways marked by cones, changing direction according to changes in rhythm, and participating in a rhythmic-train game. The fourth session emphasized turn-taking, social interaction, and impulse control through taking turns playing percussion instruments, rhythmic question-and-answer activities, transferring rhythmic patterns around the group, and group imitation. The fifth session was designed to strengthen working memory, sequencing, and motor planning by requiring children to reproduce increasingly complex three- to five-beat patterns, combine clapping with foot movements and jumping, continue previously presented patterns, and execute sequences represented on visual cards. The sixth session concentrated on response inhibition and behavioral self-control through rhythmic statue games, starting and stopping movements in response to music, changing actions according to colored cards, and following simple reversed-response rules. The

seventh session focused on rhythmic creativity, self-confidence, and social participation by encouraging each child to construct a short rhythmic pattern for other group members to reproduce and by incorporating rhythmic question-and-answer exercises and controlled creative movement to music. The final session was devoted to reviewing and consolidating the acquired skills and assessing changes in the children's performance. Previously practiced activities were repeated, children completed simple and relatively complex rhythm-imitation tasks, and a final group activity was conducted. Progress across the intervention was evaluated in terms of rhythm imitation, auditory attention, movement coordination, sequencing, stopping and starting responses, impulse control, and active participation. The control group did not participate in the RhythmoGame sessions during the intervention period and continued with its usual educational activities.

2.4. Data Analysis

The collected data were analyzed using descriptive and inferential statistical procedures. Descriptive statistics, including the mean and standard deviation, were calculated to summarize spelling learning disorder scores and their constituent dimensions at the pretest and posttest stages for the intervention and control groups. Because the primary purpose of the study was to determine whether participation in the RhythmoGame program resulted in a reduction in spelling learning difficulties after accounting for participants' initial levels of performance, analysis of covariance (ANCOVA) was used as the principal inferential statistical procedure. In this analysis, the posttest spelling score was considered the dependent variable, group membership was entered as the independent variable, and the corresponding pretest score was entered as the covariate. This procedure made it possible to statistically adjust posttest scores for baseline differences and provide a more precise estimate of the effect attributable to the RhythmoGame intervention. Where the dimensions of spelling difficulties were analyzed simultaneously, multivariate analysis of covariance (MANCOVA) could be applied to examine intervention effects across visual memory, visual sequential memory, auditory memory, auditory sensitivity, attention, educational spelling difficulties, and dysgraphia-related performance. Prior to conducting the covariance analyses, the relevant statistical assumptions, including normality of score distributions, homogeneity of variances, homogeneity of regression

slopes, linearity between the covariate and dependent variables, and independence of observations, were examined. For multivariate analyses, the homogeneity of covariance matrices was also evaluated. Statistical significance was determined at the .05 level, and appropriate effect-size indices were considered in interpreting the magnitude of the observed intervention effects.

3. Findings and Results

The participants consisted of 30 first-cycle primary school students with spelling learning disorders in Sabzevar, Iran, who were assigned to the RhythmoGame intervention

group and the control group, with 15 students in each group. The participants were between 6 and 9 years of age. In the intervention group, the mean age was 7.47 years ($SD = 0.83$), while the mean age of the control group was 7.53 years ($SD = 0.92$), indicating that the two groups were relatively comparable in terms of age. Regarding grade level, the intervention group included 5 first-grade students (33.3%), 6 second-grade students (40.0%), and 4 third-grade students (26.7%), whereas the control group included 5 first-grade students (33.3%), 5 second-grade students (33.3%), and 5 third-grade students (33.3%). The distribution of demographic characteristics indicated no substantial baseline differences between the two groups.

Table 1

Descriptive Statistics for Spelling Learning Disorder Scores in the Intervention and Control Groups

Variable	Group	Pretest Mean	Pretest SD	Posttest Mean	Posttest SD
Visual Memory	RhythmoGame	8.73	1.58	5.20	1.32
Visual Memory	Control	8.60	1.50	8.13	1.46
Visual Sequential Memory	RhythmoGame	8.27	1.49	4.93	1.28
Visual Sequential Memory	Control	8.20	1.42	7.93	1.39
Auditory Memory	RhythmoGame	7.87	1.41	4.80	1.21
Auditory Memory	Control	7.73	1.39	7.47	1.30
Auditory Sensitivity	RhythmoGame	7.53	1.36	4.47	1.19
Auditory Sensitivity	Control	7.47	1.30	7.13	1.25
Attention	RhythmoGame	8.13	1.46	4.73	1.22
Attention	Control	8.07	1.39	7.73	1.33
Educational Spelling Difficulties	RhythmoGame	8.47	1.55	5.07	1.28
Educational Spelling Difficulties	Control	8.33	1.45	8.00	1.36
Dysgraphia-Related Difficulties	RhythmoGame	7.80	1.37	4.87	1.19
Dysgraphia-Related Difficulties	Control	7.73	1.33	7.47	1.25
Total Spelling Learning Disorder	RhythmoGame	56.80	6.42	34.07	5.26
Total Spelling Learning Disorder	Control	56.13	6.18	53.87	5.94

As shown in Table 1, the pretest scores of the intervention and control groups were relatively similar across all dimensions of spelling learning disorder. However, substantial differences emerged at the posttest stage. The mean total spelling learning disorder score in the RhythmoGame group decreased from 56.80 ($SD = 6.42$) at pretest to 34.07 ($SD = 5.26$) at posttest, whereas the corresponding score in the control group showed only a slight decrease from 56.13 ($SD = 6.18$) to 53.87 ($SD = 5.94$). A similar pattern was observed across the individual dimensions. For example, visual memory difficulties in the intervention group decreased from 8.73 to 5.20, visual sequential memory difficulties decreased from 8.27 to 4.93, auditory memory difficulties decreased from 7.87 to 4.80, and attention-related difficulties decreased from 8.13 to 4.73. In contrast, only minor changes were observed in the

control group. These descriptive findings indicate that participation in the RhythmoGame program was associated with a marked reduction in spelling-related learning difficulties.

Before conducting the analysis of covariance, the relevant statistical assumptions were examined. The normality of the distribution of the dependent variable was assessed using the Shapiro–Wilk test, and the results were nonsignificant for both the intervention and control groups at the pretest and posttest stages ($p > .05$), supporting the assumption of normality. Levene’s test for equality of error variances was also nonsignificant for the total spelling learning disorder score ($F = 0.84$, $p = .368$), indicating homogeneity of variances across the two groups. The interaction between the pretest score and group membership was not statistically significant ($F = 1.17$, $p = .289$), confirming the assumption

of homogeneity of regression slopes. Examination of scatterplots indicated an approximately linear relationship between pretest and posttest scores, and no substantial outliers were identified. In addition, the observations were

independent because each participant contributed data independently of the other participants. Therefore, the principal assumptions required for conducting analysis of covariance were adequately satisfied.

Table 2

Analysis of Covariance for the Effect of RhythmoGame on Posttest Spelling Learning Disorder Scores

Source	Sum of Squares	df	Mean Square	F	p	Partial η^2
Pretest	286.42	1	286.42	13.68	.001	.336
Group	2745.63	1	2745.63	131.13	< .001	.829
Error	565.35	27	20.94	—	—	—
Total	68592.00	30	—	—	—	—
Corrected Total	3618.74	29	—	—	—	—

The results of the analysis of covariance presented in Table 2 demonstrated a statistically significant effect of group membership on posttest spelling learning disorder scores after controlling for pretest differences, $F(1, 27) = 131.13$, $p < .001$, partial $\eta^2 = .829$. The large partial eta-squared value indicates that approximately 82.9% of the adjusted variance in posttest spelling learning disorder scores was associated with the intervention-group difference after the effect of baseline scores had been statistically controlled. The pretest score also had a statistically significant relationship with posttest performance, $F(1, 27) = 13.68$, $p = .001$, partial $\eta^2 = .336$. Comparison of the adjusted posttest means indicated that students who participated in the RhythmoGame intervention had substantially lower spelling learning disorder scores than students in the control group. Therefore, the findings supported the effectiveness of the RhythmoGame method in reducing spelling learning difficulties among first-cycle primary school students.

4. Discussion

The present study investigated the effectiveness of the RhythmoGame method in reducing spelling learning disorders among first-cycle primary school students. The findings indicated that students who participated in the RhythmoGame intervention demonstrated a substantial reduction in spelling learning disorder scores compared with students in the control group. Descriptive results showed that the intervention group experienced marked improvements from pretest to posttest across the major components of spelling performance, including visual memory, visual sequential memory, auditory memory, auditory sensitivity, attention, educationally related spelling difficulties, and dysgraphia-related performance. In contrast, the control

group displayed only minor changes over the same period. The analysis of covariance further confirmed that, after statistically controlling for pretest scores, the difference between the two groups at posttest was significant. The intervention effect was also large, indicating that participation in the RhythmoGame program accounted for a substantial proportion of the variance in post-intervention spelling learning disorder scores. Overall, these results support the effectiveness of a structured rhythm- and game-based intervention for reducing spelling difficulties in young primary school students.

The findings are consistent with previous research showing that spelling learning disorders are responsive to structured and targeted educational interventions. For example, direct instruction, phonological-awareness training, and combinations of these approaches have been found to reduce spelling problems among elementary school students (Karimi et al., 2011). Similarly, a combined program integrating direct instruction and phonological awareness has been reported to decrease spelling errors among students diagnosed with spelling learning disorder (Ghanizadeh Bidokhti, 2023). Although the RhythmoGame intervention differs from these approaches in its emphasis on rhythm, movement, and game-based activity, the findings are compatible with the broader principle that systematic, repeated, and skill-focused training can improve spelling performance. One possible explanation is that RhythmoGame indirectly strengthens several cognitive processes that support the accurate conversion of spoken language into written form, including attention, auditory discrimination, sequential processing, working memory, and response control.

The effectiveness of the intervention may also be understood in relation to the cognitive foundations of

spelling. Contemporary evidence indicates that spelling development is influenced by both language-specific abilities and broader cognitive functions. Early cognitive processes have been shown to predict later reading and spelling outcomes, highlighting the importance of working memory, phonological processing, attention, and related cognitive abilities in literacy acquisition (Sigmund et al., 2024). Likewise, research on predictors of reading and spelling difficulties has demonstrated that both specific linguistic capacities and general cognitive skills contribute to the emergence of literacy problems (Pasqualotto & Venuti, 2024). From this perspective, the reduction in spelling difficulties observed in the present study may have resulted from the simultaneous activation of several general cognitive systems during rhythmic activities. Children were required to listen carefully, remember sequences, reproduce patterns, inhibit inappropriate responses, and adjust their actions according to changing auditory and visual cues. These activities may have strengthened the cognitive organization needed for accurate spelling.

The present results are also theoretically consistent with evidence showing that individuals with literacy disorders have heterogeneous cognitive profiles rather than a uniform pattern of global cognitive weakness. Research examining intelligence profiles among individuals with dyslexia suggests that learning disorders involve differentiated cognitive strengths and vulnerabilities (Radtke et al., 2025). This perspective is important for interpreting the present findings because RhythmoGame does not rely on a single cognitive route. Instead, it integrates auditory, visual, motor, temporal, attentional, and social processes. Such an intervention may therefore be particularly suitable for students whose spelling difficulties arise from different combinations of cognitive weaknesses. A child with relatively weak auditory sequencing, for example, may benefit from rhythm imitation tasks, whereas a child with attention or inhibitory-control difficulties may benefit from movement-and-stop activities and rule-changing games. The multidimensional nature of the intervention may consequently explain its broad effect across several spelling-related dimensions.

The findings also align with studies supporting multisensory educational approaches for students with learning disabilities. Rosner's multisensory teaching method has been shown to reduce spelling-writing disorders among elementary school students (Oladghobad et al., 2021), while the Fernald multisensory approach has demonstrated effectiveness in improving dictation and reading problems

among students with learning disabilities (Pourkamali et al., 2022). These approaches are based on the integration of multiple sensory pathways during learning, thereby increasing opportunities for information to be encoded and retrieved through different channels. RhythmoGame similarly involves multisensory processing because children simultaneously hear rhythmic patterns, observe demonstrations, move their bodies, use tactile and kinesthetic feedback, and respond to visual or auditory cues. Such multisensory stimulation may strengthen memory traces and improve the integration of perceptual information required for spelling.

The observed improvement in visual memory and visual sequential memory may be particularly related to the sequencing requirements incorporated into the intervention. Rhythmic patterns are inherently ordered in time, and successful reproduction requires the child to encode and maintain the correct sequence of beats and movements. Similar sequencing demands exist in spelling, where letters and phonological units must be arranged in a precise order. Difficulties in sequence retention can result in omissions, reversals, substitutions, or incorrect ordering of letters. Exercises requiring children to reproduce three- to five-beat patterns, follow visual cards, and combine clapping, stepping, and jumping in predetermined sequences may have strengthened sequential organization and short-term memory processes. This explanation is consistent with theoretical approaches to spelling remediation that emphasize the role of visual memory, auditory discrimination, attention, and sequencing in dictation performance (Tabrizi, 2011). It is also compatible with analyses of spelling errors showing that elementary students' errors can reflect problems in perceptual, linguistic, and sequential processing (Zareifard & Tadayon, 2024).

The significant reduction in auditory memory and auditory sensitivity difficulties may be related to the strong auditory component of RhythmoGame. Throughout the intervention, participants were repeatedly required to listen to auditory stimuli, distinguish specific sounds, identify changes in rhythmic patterns, and reproduce what they had heard. Such activities may enhance auditory attention and discrimination, both of which are necessary for successful spelling. Accurate dictation requires children to differentiate speech sounds and preserve their sequence long enough to convert them into written symbols. The present findings therefore suggest that rhythm-based auditory exercises may provide a functionally relevant form of practice for children

whose spelling difficulties involve weak auditory processing.

The improvement in attention observed in the intervention group may also represent an important mechanism underlying the overall reduction in spelling difficulties. Several RhythmoGame activities specifically required sustained and selective attention. Children had to respond only when a target sound was presented, stop when music ceased, change movements when a cue changed, and follow increasingly complex rules. These demands are similar to executive and attentional processes required during spelling tasks. A student writing from dictation must attend selectively to the teacher's verbal input, ignore irrelevant classroom stimuli, retain the target word, and coordinate writing without losing track of the phonological sequence. The present result is broadly compatible with research showing that game-based practice of motor skills can improve both motor and cognitive functioning in children with attention-related difficulties (Najafi et al., 2024). It therefore appears plausible that the attentional demands of rhythm-based games contributed to improved spelling performance.

The findings also support the value of integrating movement and perceptual-motor activity into interventions for academic learning disorders. Previous research has demonstrated that training perceptual-motor skills can improve reading, writing, and mathematics performance in students with specific learning disorder (Naderi et al., 2018). Visual-motor integration has similarly been emphasized as an important neuropsychological process in children with developmental coordination difficulties (Niknasab et al., 2023). Writing is not exclusively a linguistic task; it also involves coordinated perception, spatial organization, motor planning, and fine-motor execution. RhythmoGame required children to synchronize body movements with external cues, coordinate movements in space, and alter motor responses in accordance with changing patterns. These activities may enhance general perceptual-motor organization, which in turn may facilitate written performance and reduce dysgraphia-related spelling difficulties.

The present findings are additionally consistent with research indicating that game-based interventions can improve spelling performance. Word-play training has been shown to reduce spelling problems among first-grade elementary students (Ghaffari et al., 2020), and flashcard training has been found to improve written learning disorders in spelling (Abrishamizadeh, 2017). These studies demonstrate that changing the format of instruction and

increasing active engagement may improve students' responsiveness to remedial learning. RhythmoGame extends this principle by embedding learning-related cognitive exercises within rhythmic and physically active games. Compared with repetitive written practice, game-based activities may be more attractive to young children and may increase persistence, motivation, and active participation. This may be particularly important for students with learning disorders, who often have repeated experiences of difficulty in conventional academic settings.

The effectiveness of RhythmoGame can also be interpreted in light of previous findings on rhythmic and movement-based interventions. Rhythmic and group games have been reported to improve gross motor skills and social interaction in children with autism (Daneshyar et al., 2019). Although the population and outcomes differ from those in the present study, this evidence demonstrates that rhythmic activities can influence motor organization, imitation, attention, and interpersonal engagement. In the present intervention, children participated in group rhythm imitation, turn-taking, rhythmic question-and-answer exercises, and collective movement. These activities may have increased both cognitive engagement and behavioral regulation, thereby improving the learning conditions under which spelling-related processes could be strengthened.

Similarly, educational-sport games and rhythmic movements have been shown to improve mathematics skills among students with mathematics learning disorder (Zoghi et al., 2020). This finding is particularly relevant because it suggests that rhythm and movement may influence academic learning outcomes beyond the motor domain. The beneficial effect may be mediated by domain-general functions such as sequencing, attention, working memory, response inhibition, and temporal organization. The present results extend this line of evidence to spelling learning disorder and suggest that rhythm-based interventions may be applicable to different types of academic learning difficulties. The common mechanism may lie in strengthening cognitive functions that support multiple forms of academic performance.

The present findings are also compatible with recent developments in rhythm-based game learning. Game-based rhythm activities have been used to support learners in musical contexts, with an emphasis on motivation, structured practice, timing, and active engagement (Athalia et al., 2024). Although the immediate learning goal in such settings differs from spelling, the underlying processes are comparable. Rhythm games require anticipation, temporal

precision, repetition, memory, and rapid response to cues. These cognitive demands overlap with skills needed for accurate spelling and may help explain why the intervention was effective in the present study.

Another possible explanation for the observed effects concerns the gradual progression of task difficulty. The RhythmoGame protocol moved from simple imitation and basic beat recognition to more complex sequencing, response inhibition, rule changes, and creative rhythm production. Such graded practice may have allowed children to experience repeated success before confronting more difficult tasks. This progression is important in learning-disorder intervention because excessively difficult tasks may increase frustration and disengagement, whereas carefully structured tasks can preserve motivation while expanding capacity. The intervention may therefore have been effective not only because of its specific cognitive content but also because of its instructional structure.

5. Conclusion

Taken together, the results suggest that RhythmoGame may be conceptualized as a multimodal intervention rather than a purely musical or recreational activity. Its effects on spelling can plausibly be attributed to the combined activation of auditory discrimination, visual sequencing, attention, working memory, motor coordination, inhibitory control, and active engagement. This interpretation integrates several strands of previous research showing the effectiveness of phonological instruction ([Ghanizadeh Bidokhti, 2023](#); [Karimi et al., 2011](#)), multisensory teaching ([Oladghobad et al., 2021](#); [Pourkamali et al., 2022](#)), perceptual-motor training ([Naderi et al., 2018](#)), and game-based methods ([Abrishamizadeh, 2017](#); [Ghaffari et al., 2020](#)). The present study therefore contributes to the existing literature by suggesting that a rhythm-centered intervention can combine several of these therapeutic and educational mechanisms in a developmentally engaging format for young children.

The findings of this study should be interpreted in light of several limitations. First, the study was conducted with a relatively small sample of primary school students from one geographical area, which limits the generalizability of the findings to students in other cities, educational systems, or cultural contexts. Second, the quasi-experimental design reduced the degree of experimental control compared with a fully randomized clinical or educational trial. Third, the study focused primarily on immediate pretest–posttest

changes and did not include a long-term follow-up assessment; therefore, the stability of the observed improvement over time remains uncertain. Fourth, spelling performance was assessed using a researcher-developed measure, and although evidence of content validity and test–retest reliability was obtained, additional psychometric evaluation would strengthen confidence in the instrument. Finally, the intervention incorporated several components simultaneously, including rhythm, music, movement, group interaction, auditory attention, and motor sequencing, making it difficult to determine which specific component was most responsible for the observed effects.

Future studies should replicate the present research with larger and more diverse samples drawn from different regions, grade levels, and educational settings. Randomized controlled designs would be useful for increasing internal validity and providing stronger evidence regarding causal effects. Longitudinal studies incorporating follow-up assessments at several intervals could determine whether improvements in spelling are maintained after the intervention has ended. Future research could also compare RhythmoGame directly with established interventions such as phonological-awareness training, multisensory instruction, perceptual-motor programs, or conventional remedial spelling instruction. Component analyses would be particularly valuable for determining whether rhythm, movement, auditory training, group play, or their combination produces the greatest benefit. It would also be useful to examine potential mediators of intervention effectiveness, such as changes in working memory, auditory discrimination, attention, inhibitory control, visual-motor integration, and learning motivation.

In educational and rehabilitation settings, RhythmoGame can be considered as a complementary intervention for young students who experience persistent spelling difficulties and respond inadequately to conventional instruction alone. Learning-disability specialists, school counselors, special-education teachers, and primary school teachers can incorporate structured rhythmic activities into remedial programs, particularly exercises involving imitation of auditory sequences, movement synchronization, stop-and-start control, sequencing, and coordinated group games. The activities should be developmentally appropriate, progressively challenging, and adapted to the individual pattern of spelling errors and cognitive strengths of each child. Schools may also benefit from integrating brief rhythm-based activities into early literacy support programs in order to increase engagement and provide

multisensory practice. However, RhythmoGame should be used as part of a comprehensive educational plan rather than as a substitute for explicit spelling instruction, phonological training, or individualized remediation when these are required.

Authors' Contributions

Authors equally contributed to this article.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

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