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Investigating the Effects of Water-based Games in Improving the Reading Skills of Male Students with Dyslexia: A Pilot Study

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ABSTRACT

Objective: This study examined the effectiveness of water-based games in improving the reading skills of eight-year-old male students with dyslexia.

Method: A quasi-experimental design with pre-test and post-test measures and a control group was used. From a population of 150 second-grade male students referred to specialized learning disability centers in Hamadan in 2022, 30 students diagnosed with dyslexia were selected via convenience sampling and randomly assigned to experimental and control groups (n=15 each). The experimental group received 15 sessions of structured water-based games (three times per week), while the control group received no intervention. Data were collected using the Dyslexia Syndrome Checklist (Teacher Form; validity and reliability reported by Pakdaman Savoji, 2009), the Wechsler Intelligence Scale for Children–Revised (WISC-R; Wechsler, 1974), and the NEMA Dyslexia Scale (Karami-Nouri & Moradi, 2008). Statistical analysis was performed using MANCOVA.

Results: The results demonstrated that the experimental group achieved significantly higher overall reading performance than the control group ($F = 45.09$, $p < .01$; $\eta^2 = .62$)v Significant improvements were also observed in reading-related skills, including word reading, rhyme, picture naming, text comprehension, and word understanding ($p < .01$). However, no significant progress was found in word strings, phoneme deletion, pseudoword reading, letter symbols, or category symbols ($p > .05$).

Conclusions: The findings suggest that structured water-based games can effectively enhance reading performance in children with dyslexia, particularly in comprehension and vocabulary-related skills. However, limited improvements in phonological processing indicate that such interventions are most beneficial when combined with explicit phonological instruction.

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Introduction

The International Dyslexia Association's revised 2025 definition describes dyslexia as "a neurodevelopmental disorder involving challenges in word recognition and decoding, often due to phonological processing deficits, that can affect reading fluency, comprehension, and related language skills independent of overall cognitive ability (International Dyslexia Association, 2025). Affected children often exhibit a range of sensory-motor, cognitive, and perceptual-motor difficulties, which may be accompanied by emotional and behavioral challenges that reduce self-esteem and academic achievement, ultimately impacting psychosocial well-being (Tabrizi et al., 2022; Yaghoobi & Palangi, 2021). Building on this, children with dyslexia who do not receive timely, evidence-based support are at heightened risk for enduring achievement gaps and reduced educational and vocational opportunities (López-Zamora et al., 2025).

Given these potential long-term consequences, early interventions, including specialized educational programs and individualized tutoring, have been shown to support academic progress in children with dyslexia (The Prentice Team, 2023). At the same time, the global prevalence of dyslexia is estimated to range from 3% to 17.5% (APA, 2022), with boys being more frequently affected, and in Iran, the prevalence among school-aged children is reported to be as high as 9% (Seyf Naraghi & Nadari, 2018), underlining the public health and educational importance of effective support systems. Effective treatment therefore requires precise diagnosis and a multifactorial understanding of dyslexia (American Psychiatric Association (APA), 2022; Pennington, 2006), and three main theoretical frameworks currently explain its etiology: phonological deficits, visual-attentional impairments, and multi-causal perspectives (Hallahan, 2005).

In line with these theoretical perspectives, traditional interventions often emphasize perceptual-motor and multisensory techniques. Perceptual-motor skills such as spatial orientation, body image awareness, and visual tracking play critical roles in literacy development (Seyf Naraghi & Nadari, 2018). The multisensory method integrates visual, auditory, and tactile modalities to reinforce phoneme-grapheme associations (Hallahan, 2005), and recent evidence supports the use of multisensory (Zamani Behbahani et al., 2021), phonological (Reynolds & Werfel, 2022), memory retrieval (Li et al., 2021), and visual-motor strategies (Fusco et al., 2017) to enhance reading in children with dyslexia.

Extending beyond these traditional approaches, recent evidence shows that dual cognitive–motor training boosts reading-related skills in dyslexic children (Ramezani & Fawcett, 2024), visual–auditory accuracy training improves reading performance (Bagherinia et al., 2022), and reverse-learning instructional design enhances motivation and school connectedness (Mahmoodi et al., 2023), highlighting the growing shift toward integrated, multimodal intervention models that target both cognitive and affective outcomes.

Furthermore, play-based interventions have emerged as effective tools for addressing learning disabilities. Recent studies indicate that integrating educational content into structured play promotes skill development, motivation, and engagement in children with developmental and learning disorders (Işıtan, 2025).

In particular, aquatic and water-based programs have been shown to improve motor, social, and adaptive skills in children and adolescents with disabilities, supporting their functional participation and learning readiness (Etemadzadeh et al., 2023; Işıtan, 2025; Kemp et al., 2024; Ogonowska-Slodownik, 2024). Building on this evidence from therapeutic and inclusive settings, early childhood research highlights that water, similar to other tactile media such as clay or sand, offers unique sensory experiences and learning opportunities that support embodied cognition and early language and literacy learning (Ampartzaki et al., 2021; Nalumenya et al., 2024; Nur et al., 2019). Recent work in game- and play-based pedagogy further shows that integrating curriculum content into hands-on, exploratory activities around themes such as water and the environment can enhance children's. conceptual understanding, engagement, and emergent literacy skills (Ampartzaki et al., 2021; Crosser, 2015; Nalumenya et al., 2024; Purnamasari, 2023).

Extending these findings to classroom organization, smaller and calmer water play environments may further enhance individualized learning opportunities, particularly for children who require independent exploration. Water-based learning activities have also been associated with increased classroom participation and motivation, particularly among reluctant learners (Levy & Moore Mensah, 2021). Experimental research has demonstrated positive effects of such activities on cognitive, motor, emotional, and psychological outcomes in young children (Susanto, 2012). A growing body of literature therefore supports the effectiveness of water games in early childhood education (Alaniz & Rosenberg, 2017; Begecarslan et al., 2021; Burhaein, 2019; Cline & Smith, 2016; Hafina et al., 2020; Karklin et al., 2013; McMillan, 2014; Nur et al., 2019; Olowe et al., 2020; Ram-Tsur et al., 2013; Stan, 2012). Collectively, these studies suggest that water-based games may have a significant impact on core and related reading skills in children with dyslexia (D'Mello & Gabrieli, 2018).

In line with this broader evidence base, a recent study by Yaghoobi and colleagues (2023) examined the effects of educational interventions using water games on children with dyslexia and reported that such activities can improve the writing performance of first-year elementary school boys with dyslexia. Given that the optimal intervention window for dyslexia is before the age of ten, this study focused on early instructional support and evaluated reading performance with the standardized NEMA test, which assesses visual–auditory syllable processing and speed–accuracy processing as two core reading domains.

However, despite these promising findings, empirical research specifically targeting water-based play as a structured intervention for children with dyslexia remains scarce, both domestically and internationally, especially when compared with the rapidly expanding literature on aquatic and water-based programs for children with disabilities more generally (e.g., aquatic interventions and game-based learning approaches for special learning difficulties). Existing treatment programs for dyslexia often rely on traditional, paper-and-pencil or purely language-based methods and tend to underutilize multisensory, game- and play-based formats such as water games, which have been shown to enhance engagement, motivation, and foundational cognitive and motor skills in early childhood.

Accordingly, there is a clear need for the present study, which systematically examines the impact of structured water-based games on key reading skills in children with dyslexia, using standardized outcome measures such as the NEMA test to capture changes in visual–auditory processing and reading speed–accuracy. Building on prior work showing that NEMA-based indices of speed and accuracy are reliable markers of reading difficulties in dyslexic learners, the present intervention focused on whether a multisensory, game-based format can directly modify these core components of reading performance. By addressing this gap, the study aimed to provide evidence-based guidelines for designing multisensory, game-based reading interventions that can help children with dyslexia develop essential reading skills and move closer to achieving academic outcomes comparable to their typically developing peers.

In line with this aim, the research addressed two key questions:

(1) Do water-based games significantly improve overall reading performance in children with dyslexia, as indexed by NEMA reading scores?

(2) Do these games reduce specific symptoms of dyslexia, particularly deficits in visual–auditory syllable processing and reading speed–accuracy?

Framing the study around these questions allows for a focused evaluation of both global reading gains and targeted changes in dyslexia-related symptoms, thereby clarifying the specific contribution of water-based games within the broader landscape of dyslexia interventions.

Materials and Methods

Design

This study employed a quasi‑experimental design with a quantitative approach, using a pretest–posttest format with a control group.

Participants

From an initial population of 150 second‑grade male students referred in 2022 to the Sahel and Baran learning disorder centers in Hamadan Province, 30 students diagnosed with dyslexia were selected via convenience sampling and then randomly assigned to an experimental group (n = 15) and a control group (n = 15). All participants had an average age of 8 years. A convenience sampling method was used in this research. Students first completed the Dyslexia Syndrome Checklist, which served as a screening tool to identify those suspected of having dyslexia. The final sample size was determined using Cohen’s table for experimental research, with an alpha level of .05, a large effect size (.4), and medium power (.5), yielding 15 participants per group and a total of 30 participants (Cohen, 1988).

The selected students were then randomly allocated to the experimental and control groups. The experimental group received the water-based game intervention while the control group followed the usual instructional routine without exposure to the intervention. The inclusion criteria included: participants had no chronic illness, scored ≥85 on the WISC-R, and showed reading performance two SDs below the mean. They were monolingual Persian speakers and not involved in similar interventions, confirmed through parent interviews and the NEMA test. Participants were excluded if they missed more than two intervention sessions or expressed unwillingness to continue participating in the study.

Instruments

Dyslexia Syndrome Checklist. The 15-item dyslexia checklist helps identify reading difficulties, with students flagged if over five items are marked. It has strong reliability (.92; Pakdamen Savoji, 2000) and expert-confirmed validity (Sheykholeslami, 2017). In this study, its reliability was acceptable (Cronbach's $\alpha = .71$).

Reading test and dyslexia NEMA. This widely used Iranian dyslexia test was standardized for Persian and bilingual students (Kormi Nouri & Moradi, 2008) and applied here in its Persian version. Large-scale validation showed strong reliability ($\alpha = .82$; Moradi et al., 2016). It includes 10 subtests assessing core reading skills. Prior research reported $\alpha = .64–.99$ (Safarpour Dehkordi et al., 2011), and reliability in the present study was $\alpha = .71$.

Word reading. This subtest assesses aloud word reading across high, medium, and low frequencies, using three 40-word lists read within two minutes. It includes two interchangeable forms, A and B.

Word String. This subtest measures recognizing meaningful words hidden in letter strings. Students mark word boundaries silently within two minutes, using brief practice items before completing multiple Persian word chains.

Rhyme. This test evaluates rhyme recognition through 20 items, each with one correct rhyming option read aloud. Students choose the rhyme within a two-minute limit after completing brief practice examples.

Calling pictures. This subtest measures picture-naming speed and accuracy using two parallel 20-picture cards. Students name images aloud from right to left, top to bottom, with errors and timing recorded. Each card has a one-minute limit.

Text comprehension. This subtest evaluates listening comprehension using two narrated texts. Students hear each story and answer multiple-choice questions, with responses and timing recorded while written options remain available.

Word understanding. This subtest evaluates word comprehension through 30 multiple-choice items on meaning or usage, with questions read aloud and answers marked by the student.

Elimination of sounds. This subtest measured phoneme-deletion by having examinees repeat 30 randomized words without target sounds, completed in two minutes.

Pseudowords. This subtest assessed reading of 40 pseudowords, read in order as shown, ignoring meaning, within two minutes.

Letter signs. This subtest measures word generation by having examinees say as many words as possible starting with three presented Persian letters (م ، ا-آ ، ن).

Category signs. This test measured word generation across six categories within one minute each, totaling six minutes (Kormi Nouri & Moradi, 2008; Moradi et al., 2016).

The scoring method for each subtest was as follows: Each correct response earned one point, converted to a t-score; scores below 30 indicated dyslexia, and some subtests included time limits.

Wechsler Intelligence Scale for Children – Revised Form (WISC-*R*). The WISC-IV assesses five cognitive domains in children 6–16; adapted for Iranian children with strong reliability and validity (Cronbach's alpha: .65 to .95; split-half method: .76 to .91) (Abedi et al., 2006; Sadeghi et al., 2011; Shahim, 2004; Sharifi & Rabiei, 2013) and used to confirm dyslexic students' normal intelligence (> .85).

Procedure

The water game intervention consisted of five structured interactive games aimed at improving reading skills in dyslexic students and was implemented across 15 sessions of 45 minutes over five weeks (Table 1). Conducted in a dedicated game room, the program followed ethical approval from the Bu-Ali Sina University Ethics Committee (IR.basu.rec.1402.032) and adhered to the Declaration of Helsinki. After obtaining the required permissions, informed consent was secured from parents, who were assured of confidentiality, the research-only use of data, and their children's safety during water-based activities; they were also allowed to observe sessions.

The intervention content was derived from a second-grade Persian textbook, with sessions designed to incorporate water-based play into a structured protocol targeting cognitive, sensory, motor, and emotional skills. Five learning disorder specialists confirmed the therapeutic soundness of the session designs. The protocol included five games- *fishing, water shooting, stone letters, hidden pictures, and maze-* integrating exercises in eye tracking, body awareness, voice tracking, text comprehension, phonological skills, phonetic reservoir strengthening, and active memory enhancement.

Games took place in a classroom equipped for water activities, using simple materials such as plastic balls, spray bottles, stones, foam letters, and edible colors. Children first received a 45-minute orientation before participating individually and in groups. The control group received no additional intervention. Both groups completed the NEMA test before and after the program, administered individually by a trained examiner following standardized scoring procedures.

Table 1. Water-based games for therapeutic and educational purposes for 8-year-old dyslexic boys

Water-based games	Target group	Therapeutic goals	Educational goals	Procedure	Frequency and duration	Location	Tools
Fishing	8-year-old dyslexic boys	a-h	1-4	A picture card is shown once and then removed; the child retrieves the letters forming the target word from the water and reads them aloud; the child writes the letters on the board in the correct order; different letter shapes or words are used to reinforce learning; the child places the fish on the board and forms sentences.	Three times per week, 45 min	Water playroom	Colorful foam papers, foam glue, magnet, waterproof marker, water bowl, a board
Water Shooting		a-h	1-5	A picture card is shown once and then removed; the child reads the word aloud; using a water spray, the child shoots letter balls arranged in paper tubes following the correct letter order; word balls are used to form sentences; the child shoots the word balls according to sentence order.	Three times per week, 45 min	Water playroom	water spray paper tube, Waterproof, marker, a board
Stone Letters		a-h	1-5	A picture card is shown once and then removed; the child reads the word aloud; letter stones are dropped into glasses of water in the correct order; the child reads the formed word or sentence aloud and writes it on the board.	Three times per week, 45 min	Water playroom	Colored stones of letters or words, a few glasses of water marker, a board
Hidden Images		a-h	1-5	Picture cards are placed under a glass container filled with colored water; the child places and moves the glass container in the water to reveal the images, the child identifies the target word or letter, reads it aloud, and writes it on the board.	Three times per week, 45 min	Water playroom	A glass container filled with colored water, picture cards, a glass cup, food coloring, and a board
Maze		a-g	1,2,3,5	A picture card is shown once and then removed; letter balls corresponding to the target word are placed into a water container in order; using a straw, the child guides the letter balls through the maze until they exit the container; the child reads the word aloud and writes it on the board.	Three times per week, 45 min	Water playroom	Straw, letter ball, a water container, and a board

Note. Letters (a–h) indicate therapeutic goals, and numbers (1–5) indicate educational objectives.
a. Strengthening visual memory (visual sequence and visual distinction); **b.** Strengthening fine and gross motor skills; **c.** Strengthening sensory-motor coordination; **d.** Increasing accuracy and concentration; **e.** Strengthening spatial perception skills: Establishing lateral dominance; **f.** Strengthening listening memory: listening sequence and discrimination; **g.** Improving balance; and **h.** Distinguishing parts from the whole.

The educational goals are as follows*:* **1.** knowing different letters and their different forms; **2.** understanding visual symbols and the structure of phonemes, words, and sentences; **3.** strengthening semantics and syntax structures; and **4.** Progress in psychic reading: Progress in pronunciation; **5.** Increased reading speed.

Game stages in Procedure: The first and last stages are the same in all games (First stage: Show a picture card once and place it aside; last stage: Ask him to read the word aloud and write it on a board).

Data Analysis

The data were analyzed in SPSS 27 using descriptive and inferential statistics, confirming all assumptions- normality, outliers, homogeneity of variance, slopes, and covariance matrices- before applying ANCOVA and MANCOVA. No significant group differences appeared in dyslexia components ($p > .05$). The study had ethical approval (IR.basu.rec.1402.032).

Results

This study investigated the effectiveness of water-based games on the reading performance and reading components of 8-year-old boys with dyslexia. The mean scores and standard deviations for the experimental and control groups for the pre- and post-test stages for the improvement of dyslexia are shown in Table 2.

Table 2. Descriptive statistics of dyslexia scores in the control and experimental groups

	Group testing	Pretest			Post-test		
		Frequency	Mean	Standard deviation	Frequency	Mean	Standard deviation
Improvement of dyslexia	Experimental	15	144.23	11.73	15	167.17	13.24
	Control	15	143.61	22.30	15	146.33	12.25

Table 2 shows that the average dyslexia scores in the experimental group increased after the test compared to before the test. This index did not significantly improve after the test compared with before the test in the control group. The mean scores and standard deviations for the experimental and control groups for the pre- and post-test stages in the improvement of dyslexia subtests are shown in Figure 2.

Figure 2 shows that post-test scores increased for several components of the experimental group, such as reading words, rhyme, calling pictures, text comprehension, and word understanding. However, no change was observed in other words, such as word strings, pseudowords, elimination of sound, or signs

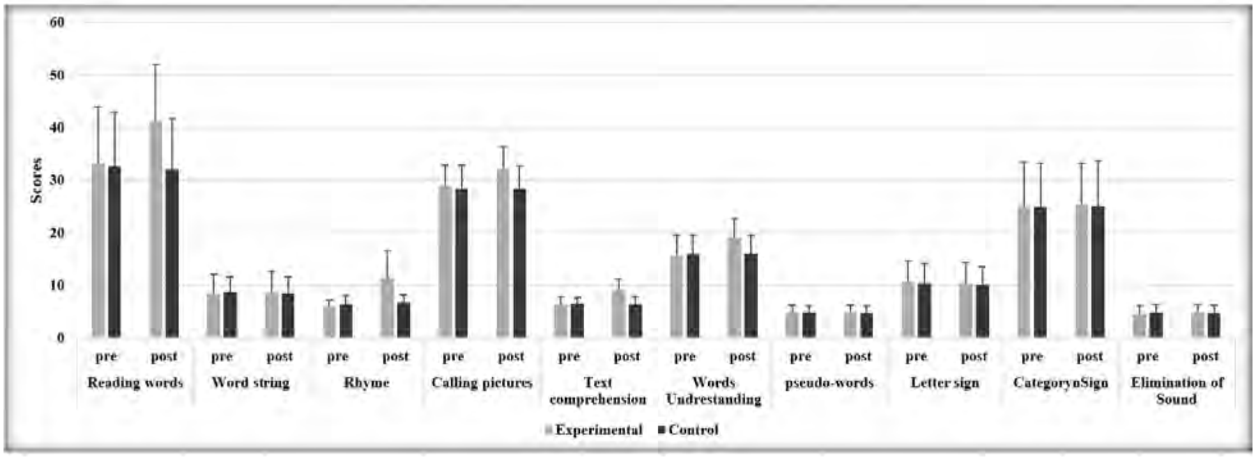

Figure 2. ***Progress in the dyslexia subtest in the control and experimental groups.***

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Analysis of the First research question: *Do water-based games significantly improve reading performance?* To answer this question, we conducted an ANCOVA with post-test dyslexia scores as the dependent variable, group (water-based games or control) as the independent variable, and pretest dyslexia scores as the covariate. Table 3 summarizes the results of the ANCOVA.

Table 3. Results of the ANCOVA for the post-test dyslexia scores, controlling for the pretest scores

Variable	Factor	Sum of squares	Degree of freedom	Mean squares	F value	Significance Level	Eta squared
Dyslexia	Pretest	1983.48	1	1983.48	20.83	.001	.43
	Group	4293.43	1	4203.43	45.09	.001	.62
	Error	2570.77	27	95.21			

The ANCOVA showed that the pretest scores were a significant covariate (F=20.83, p<.001), indicating that they had a strong influence on the post-test scores. The group effect was also significant (F=45.09, p<.001), suggesting that playing with water improved the reading performance of dyslexic boys in the second grade of elementary school. The effect size was large (.62) based on Cohen's (1988) guidelines for interpreting eta-squared values.

Analysis of the Second research question*: Do water-based games improve dyslexic symptoms?* We performed a multivariate covariance analysis (MANCOVA) with the post-test scores of the dyslexia components as the dependent variables, the group (water-based games or control) as the independent variable, and the pretest scores of the dyslexia components as the covariates. Table 4 shows the results of the multivariate tests for group effects.

The multivariate tests indicated that the group effect was significant (F = 8.65, p < .01), *indicating* a significant difference in the mean composite scores of the dyslexia components between the control and experimental groups.

Table 4. Results of the multivariate tests for the group effect on the post-test scores of the dyslexia components, controlling for the pretest scores

Index	P Value	F- Value	Degrees of freedom hypothesis	Degrees of freedom error	Significance Level
Pillai's trace	.90	8.65	10	9	.002
Wilks' Lambda	.09	8.65	10	9	.002
Hotelling's Trace	9.61	8.65	10	9	.002
Roy's largest root	9.61	8.65	10	9	.002

To examine the significance of the difference between the mean scores of each dyslexia component, we conducted a univariate ANCOVA for each component. Table 5 summarizes the results of the univariate ANCOVAs.

Table 5. Results of the univariate ANCOVAs for each dyslexia component, controlling for the pretest scores

Variable	Factor	Sum of squares	Degree of freedom	Mean squares	F value	Level of significance	Eta squared
Reading words post-test	group	598.75	1	598.75	7.23	.015	.28
	error	1489.79	18	82.77			
Word strings Post-test	group	3.37	1	3.37	.94	.344	.05
	error	64.16	18	3.56			
Rhyme post-test	group	194.11	1	194.11	16.43	.001	.47
	error	212.66	18	11.81			
Pictures naming post-test	group	71.94	1	71.94	13.84	.002	.43
	error	93.50	18	5.19			
Text comprehension Post-test	group	62.93	1	62.93	21.31	.001	.54
	error	53.16	18	2.95			
Words understanding post-test	group	80.68	1	80.68	33.13	.001	.64
	error	43.83	18	2.43			
Phoneme deletion post-test	group	.49	1	.49	.44	.513	.02
	error	19.94	18	1.10			
Pseudowords post-test	group	.05	1	.05	.28	.598	.016
	error	3.26	18	.18			
Letter symbols post-test	group	.27	1	.27	.14	.704	.008
	error	33.68	18	1.87			
Category symbols Post-test	group	.14	1	.14	.04	.828	.003
	error	54.04	18	54.04			

The results of the Univariate ANCOVA revealed that water-based games had a significant effect on the reading components of reading words (η^2=.28, p<.05; F= 7.23), rhyme (η^2=.47, p<.01; F=16.43), and picture naming (η^2=.43, p<.01; F= 13). 84), text comprehension (η^2=.54, p<.01; F=21.31), and word understanding (η^2=.64, p<.01; F=33.13) among male students with dyslexia. However, there were no significant effects of playing with water on the components of word strings, phoneme deletion, pseudowords reading, and symbols (p>.05).

Discussion

The present study aimed to examine whether water-based games could improve reading performance in second-grade boys with dyslexia. The ANCOVA results showed that participation in a structured program of water-based games led to a marked improvement in overall reading performance, as measured by the NEMA test, with a large effect size ($\eta^2 = .62$). This finding suggests that learning activities embedded in playful, water-based contexts can meaningfully support reading development in children with dyslexia. Beyond overall reading performance, the intervention resulted in significant gains in specific reading-related skills, including word reading, rhyming, picture naming, text comprehension, and word understanding. In contrast, no significant changes were observed in phoneme deletion, word strings, pseudowords, or symbol recognition. This pattern of results can be better understood when considered in light of existing cognitive and linguistic theories of reading development and dyslexia.

Previous studies have consistently shown that water-based activities promote cognitive engagement, language development, and vocabulary growth in young children (Begecarslan et al., 2021; Hafina et al., 2020; Olowe et al., 2020). Although these studies were not primarily focused on children with dyslexia, they highlight the role of enriched, sensory-rich environments in facilitating learning. Our findings extend this line of research by suggesting that such environments may also benefit children with dyslexia, particularly in reading-related domains that rely on vocabulary, semantic processing, and meaning construction. The positive outcomes observed in this study are also consistent with earlier intervention research in play therapy and hydrotherapy (Crosser, 1994; Hafina et al., 2020; Nur et al., 2019; Ram-Tshur et al., 2013; Yaghoobi et al., 2023), further supporting the educational potential of play-based and water-based approaches.

From a cognitive–linguistic perspective, dyslexia affects key components of reading such as word recognition, rhyming, and picture naming, all of which are closely linked to broader cognitive skills, including decoding, spelling, and fluent access to lexical representations (Moradi, 2016). The improvements observed in these areas suggest that water-based games may indirectly strengthen the cognitive foundations of reading by enhancing attention, memory, and vocabulary awareness. In particular, activities involving word decomposition and combination within water-based games appear to have supported children's understanding of word structure and meaning, which in turn contributed to better text comprehension and word understanding.

Reading is commonly described as involving two main components: decoding and comprehension (Sermier Dessemontet et al., 2017). Decoding relies heavily on phonological processing skills such as segmenting and blending sounds, whereas comprehension draws on higher-level language and cognitive abilities. According to the Simple View of Reading, difficulties in reading may arise from weaknesses in decoding, language comprehension, or both (Hsu et al., 2023; Sleeman, 2022). The pattern of results in the present study suggests that water-based games may be particularly effective in supporting the comprehension-related component of reading. Through activities that involved picture interpretation, sentence formation, and contextual word use, students were encouraged to actively construct meaning, which likely strengthened their semantic and syntactic processing.

At the same time, the lack of significant improvement in phoneme deletion and pseudoword reading aligns with research showing that deficits in phonological awareness are a core feature of dyslexia (Brèthes et al., 2022; Fusco et al., 2017). These skills require rapid and automatic phonological processing, which may not be sufficiently addressed through general play-based activities alone. Although some of the water-based games in this intervention targeted phoneme manipulation—such as identifying letters in the "fishing" game or forming words in the "water-shooting" game—the results suggest that more explicit and intensive phonological instruction may be necessary to produce measurable gains in these specific reading subcomponents.

Another important dimension of dyslexia relates to phonological difficulties that stem from broader challenges in speech–motor coordination, auditory processing, syntactic organization, and semantic integration (Pennington, 2006; Shojaee & Hemmati, 2017). The "maze" game was designed with this perspective in mind, combining physical movement with cognitive and linguistic tasks. Engaging the body alongside the mind may have supported improvements in motor control, visual tracking, and memory, which are known to play a supporting role in reading development. These gains may help explain the observed improvements in reading fluency and comprehension, even in the absence of strong effects on more automatic phonological tasks.

Finally, the absence of significant effects in tasks such as phoneme deletion, word strings, pseudowords, and symbol reading may also be related to processing speed and fatigue. Lexical processing speed and accuracy are critical for these components of reading (Kormi Nouri & Moradi, 2008). In this study, the intervention sessions were conducted after academic or physical education classes, which may have reduced students' available cognitive resources– Previous research has shown that fatigue negatively affects attention, processing speed, and visual information processing in school-aged children (Boksem et al., 2006; Junnan et al., 2016; Li et al., 2020; Masaaki et al., 2012; Mizuno et al., 2011; Nijhof et al., 2016; Sulheim et al., 2016). It is, therefore, plausible that fatigue limited students' performance on tasks requiring rapid and effortful phonological processing.

In summary, the findings of this study suggest that water-based games can serve as an effective complementary approach for improving reading performance in children with dyslexia, particularly in areas related to vocabulary, meaning-making, and comprehension. However, these activities alone may not be sufficient to address deficits in automatic phonological processing. Integrating water-based, multisensory activities with targeted phonological interventions may provide a more comprehensive and effective framework for supporting *reading development in children with* dyslexia**.**

Conclusion

The present study investigated the effects of structured water-based games on reading performance in second-grade boys with dyslexia. The results demonstrated that participation in water-based, play-oriented activities led to a significant improvement in overall reading performance as measured by the NEMA test, with a large effect size. This finding supports the effectiveness of multisensory, game-based learning environments in promoting reading development in children with dyslexia, particularly when implemented as early interventions (D'Mello & Gabrieli, 2018; Hallahan, 2005; Zamani Behbahani et al., 2021). At the component level, significant gains were observed in word reading, rhyming, picture naming, text comprehension, and word understanding. These improvements suggest that water-based games are especially effective in supporting vocabulary development, semantic processing, and meaning construction. This pattern is consistent with previous research indicating that play-based and water-based activities enhance language and cognitive development through increased engagement and sensory-rich learning experiences (Ampartzaki et al., 2021; Begecarslan et al., 2021; Hafina et al., 2020; Nur et al., 2019). In contrast, no significant effects were found for phoneme deletion, pseudoword reading, word strings, or symbol-related tasks. These skills rely heavily on automatic phonological processing, which is known to be a core deficit in dyslexia (Brèthes et al., 2022; Fusco et al., 2017; Pennington, 2006).

From the perspective of the Simple View of Reading, the intervention primarily strengthened language comprehension rather than decoding abilities (Sermier Dessemontet et al., 2017; Sleeman, 2022). This suggests that water-based games should be viewed as a complementary approach rather than a standalone treatment.

Several limitations should be considered. The study involved a small, gender-specific sample and a relatively short intervention period, limiting generalizability and conclusions about long-term effects. Additionally, fatigue during sessions may have influenced performance on tasks requiring rapid processing (Boksem et al., 2006; Li et al., 2020; Mizuno et al., 2011). Future research should include larger and more diverse samples, longer interventions, and follow-up assessments. Integrating water-based games with explicit phonological instruction may provide a more comprehensive framework for supporting reading development in children with dyslexia (APA, 2022; Reynolds & Werfel, 2022).

Author Contributions

All authors significantly contributed to this study.

Data Availability Statement

The datasets generated and/or analysed during the current study are available from the corresponding author upon reasonable request.

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Ethical Considerations

This study was conducted in accordance with ethical principles and received approval from the Research Ethics Committee of Bu-Ali Sina University, Hamadan, under the ethics code IR.BASU.REC.1402.032. Participants had the right to withdraw from the study at any time. All parents were informed about the study, and the confidentiality of all participants' information was maintained.

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Conflicts of Interest

The authors report no conflicts of interest.

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