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Effectiveness of Proprioception-Enhancing Exercises on Dyslexia and Dysgraphia in Students with Specific Learning Disorder

Tahmineh Changizi, Ph.D. Candidate
Farah Naderi, Ph.D.
Rezvan Homaei, Ph.D.
Sasan Bavi, Ph.D.
Department of Psychology, Ahvaz Branch, Islamic Azad University, Ahvaz, Iran

Abstract

Students with specific learning disorders (SLD) have major difficulties in learning and using listening, speaking, reading, writing, and math skills. The present study aimed to investigate the effectiveness of proprioception-enhancing exercises on dyslexia and dysgraphia in students with SLD. The research method was quasi-experimental with a pretest-posttest design and a control group. The study population consisted of all girl and boy elementary school students (2nd and 3rd grades) with SLD who received educational and rehabilitation services from public and private centers for learning disorders in Ahvaz, Iran in 2022. Using convenience sampling, 30 students were selected and randomly assigned to the experimental and control groups (n= 15 per group). The participants in the experimental group received proprioception-enhancing exercises in twelve 45-minute sessions, whereas those in the control group received no intervention. The research instruments included the Reading and Dyslexia Test and Dysgraphia Test. The data were statistically analyzed using analysis of covariance (ANCOVA). According to the demographic results, the mean age of the students in the experimental and control groups was 8.64±2.31 and 8.30±2.47 years, respectively. The results showed that proprioception-enhancing exercises were effective in improving dyslexia and dysgraphia in students with SLD ($p<0.01$). It can be hence concluded that proprioception-enhancing exercises improve not only dyslexia and dysgraphia in students with SLD but also their academic performance.

Keywords: Dyslexia, Dysgraphia, Proprioception-enhancing, Specific learning disorder, Students

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Corresponding Author: Farah Naderi
Email: naderifa2@gmail.com

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Introduction

Specific learning disorder (SLD) refers to students who consistently fail in their academic activities but cannot be included in the age framework of exceptional children (Yakut, 2021). The prevalence of SLD among school-age children ranges from 3% to 16.5%, and it is more common among boys than girls (Chacko & Vidhukumar, 2020). The prevalence of SLD in Iran has been reported 4.5% to 7% (Esmaili et al., 2016). Students with SLD exhibit major difficulties in learning as well as listening, speaking, reading, writing, and math skills (Norozbakhsh et al., 2021; Woodcock & Faith, 2021).

Studies have shown that dyslexia is the most common problem among those with SLD as about 80% of students with SLD suffers from dyslexia. Reading

problems are among the most basic issues of students with SLD (Kim, 2021). Dyslexia is a learning disorder that involves difficulty reading. Although this disorder has long been considered purely cognitive, evidence suggests that dyslexia, as a developmental disorder, is associated with sensory disorders (Snowling et al., 2020). Dyslexia is limited to visual and auditory processing, two senses that play a significant role in reading. The cognitive theory posits that such disorders originate from a lack of reading, whereas the sensory theory holds that sensory disorders caused by damage to neural mechanisms are responsible for dyslexia (Bagheri Nia et al., 2022). Cheng et al. (2022) stated that although dyslexics recognized strong stimuli as much as the control group did, they had significant difficulties with recognizing weaker stimuli. They also concluded that there was a positive relationship between visual processing and reading abilities. Although these results cannot be explained by a lack of reading, they confirm the sensory theories of dyslexia (Cheng et al., 2022).

Another complication of SLD is dysgraphia. Many studies have dealt with reading problems, whereas fewer studies have investigated writing disorders. Most students with dysgraphia also have problems with writing and spelling. Similar to reading, writing is also necessary for students in the learning process (Chung et al., 2020; McCloskey & Rapp, 2017). Writing problems can affect children's other educational activities at school and also endanger their professional and social success. The ability to write is associated with skills such as proper understanding of words, legible writing, and grammar. The major problems in writing can be divided into three groups: (1) illegible or bad handwriting, (2) spelling disorder, and (3) errors in composition writing (Drotár & Dobeš, 2020; Wang et al., 2022).

Students with SLD may also face the side issue of sensorimotor dysfunctions (Habib, 2021). Sensorimotor functions are dependent on the sensory systems that living beings use as resources to obtain information from the surrounding environment, provide appropriate responses, and successfully adapt to environmental needs (Blanchet & Assaiante, 2022). The sensory system in humans provides passages for the brain to receive information, interpret stimuli, and provide responses (Camarata et al., 2020). Proprioception is the most important sensory channel involved in the development of basic senses. Humans take advantage of proprioceptive information to develop their body coordination, balance, and motor skills (Quinn, 2009; Vinutha et al., 2021).

Proprioception refers to the sense that lets us perceive the location, movement, and action of parts of our body such as joints and muscles, and proprioceptors include muscle spindles, Golgi tendon organs (GTOs), and mechanoreceptors. Proprioceptors cooperate with the vestibular system to create a sense of balance and position in space. Although all muscles and joints are involved in this process, the neck joints and proximal joints of the hip and shoulder play a more important role and provide the most feedback to the central nervous system (CNS). Proprioception disorder is another type of sensory problem that prevents the correct transmission of information from muscles and joints to the brain (Moon et al., 2021; Ouellet et al., 2021; Tuthill & Azim, 2018). Children who do not receive correct information about their body position often seem distracted and perform tasks very slowly. Such children also use excessive or insufficient force for some activities such as sitting, touching, walking, or eating. Many students with proprioception disorders may enjoy the application of pressure to their skin or repeated muscle contractions; for example, they like to lean on another child or hang from the classroom door frame. Such behaviors may be misinterpreted as behavioral disorders, but they are related to proprioception (Janmohammadi et al., 2020; Rosenbaum et al., 2021). Studies about the effects of sensory integration on students with SLD have confirmed the effectiveness of this method in improving learning disorders (Agostine et al., 2022; Crasta et al., 2020; Faramarzi, 2020; Mahmoodi et al., 2019).

Proprioception has the greatest effect on the learning process of students. In general attention and concentration on the basic senses and linking these senses and the second-level senses lead to coordinated processing and facilitate learning reading and writing skills. Although experts and educators have long been working on students' sensory integration in Iran and many studies have been conducted on this subject, few studies have dealt with proprioception. Accordingly, the present study aimed to investigate the effects of proprioception-enhancing exercises on dyslexia and dysgraphia in students with SLD.

Method

Design

The research method was a pretest-posttest study with control and experimental groups.

Participants

The study population included all female and male elementary school students (2nd and 3rd grades) with SLD who received educational and rehabilitation services from public and private centers for learning disorders in Ahvaz, Iran in 2022. The inclusion criteria were parental consent for the participation of their children in the

study, diagnosis of dyslexia and dysgraphia in the children, and non-affliction with autism, mental retardation, intellectual disability, and other psychiatric disorders. The exclusion criteria were parents' unwillingness to allow their children to remain in the research, children being under drug therapy, and absence in more than two sessions. Accordingly, 30 students who met the inclusion criteria were selected as the sample through convenience sampling and were randomly assigned to the experimental group (proprioception-enhancing exercises) and the control group (15 participants in each group). The participants in the experimental group attended a group intervention of proprioception-enhancing exercises led by the researcher who had passed treatment courses and attended specialized workshops. To observe ethical considerations, those in the control group attended an intensive course on proprioception-enhancing exercises at the end of the study.

Instruments

The research instrument consisted of the Reading and Dyslexia Test and Dysgraphia Test. Moradi et al. (2016) normalized the Reading and Dyslexia Test for dyslexia assessment in male and female elementary school students, both monolingual (Farsi) and bilingual (Azeri and Kurdish). This test consists of 10 subscales: reading words, word chain, rhyme test, naming pictures, text comprehension, word comprehension, elision, reading non-words, letter signs, and category signs. The reliability of this scale was confirmed by Moradi et al. (2016) (α=0.97). The test of diagnostic dictation disorders was employed to measure dysgraphia. Jabbari (2017) normalized this test on 2403 elementary schools (third, fourth, fifth, and sixth grades). Jabbari (2017) reported an alpha Cronbach coefficient of .93 for the tool.

Intervention Program

Proprioception-enhancing exercises: The Bruininks-Oseretsky Test of Motor Proficiency (Bruininks & Bruininks, 2005) was performed in twelve 45-minute sessions twice a week (Table 1).

Table 1
Proprioception-Enhancing Exercises

Sessions	Proprioception exercise
1	Familiarization with the parents and students, evaluation of Bruininks-Oseretsky test (BOT) of motor proficiency
2	Touching the nose with a finger - touching the tips of the fingers - jumping over a therapy ball
3	Moving coins and matchsticks - Stacking matchsticks - Putting matchsticks in the box - Putting coins in the box
4	Resistance exercises (pulling and pushing objects) - Alternate clasping of hands - Tie and untie
5	Hitting and shooting the ball - Throwing the ball at the target – Throwing and getting the ball – Carrying a bag of beans on the back
6	Passing the maze - Sculpture activity - Finger waving - Walking back and forth alone with eyes open and closed
7	Jumping and touching the heels - Passing the maze – Alternately clenching and unclenching the fists - Crawling through the tunnel
8	Moving coins and matchsticks - Stacking matchsticks - Putting matchsticks in the box - Putting coins in the box
9	Jumping rope - Spiral activity - Station activity - Using a THERABAND
10	Wrapping the thread around the spool - Wrapping the thread around the spool while moving - Wrapping the thread around the spool with eyes closed - Tying and untying the bolt and nut with eyes closed
11	Alternate clasping of hands - Reaching the tips of the fingers above the head with eyes open and closed - Animal imitation game
12	Alternate clasping of hands – Drawing a circle in the air - Resistance exercises (pulling and pushing objects) - Rhythmic strokes with fingers

Statistical Analyses

The data were statistically analyzed using descriptive statistics (mean and standard deviation) and inferential statistics (analysis of covariance (ANCOVA)). The Shapiro-Wilk test was used to examine the normality of

data; and the Levene's test was utilized to investigate the homogeneity of variances.

Findings

Table 2 presents the demographics of the participants in the experimental and control groups. Table 3 also shows the mean scores and standard deviations (SD) of the research variables for both groups in the pretest and posttest.

Table 2
Demographics Variables of Students with SLD

Groups	Age (years)	Gender	
		Girl	Boy
Proprioception-enhancing exercises	8.64±2.31	7 (46.67%)	8 (53.33%)
Control	8.30±2.47	6 (40.00%)	9 (60.00%)

Table 3
Mean and Standard Deviation (SD) of Research Variable in Experimental and Control Groups

Variables	Groups	Pretest	Posttest
		Mean ± SD	Mean ± SD
Reading words	Proprioception-enhancing exercises	57.53 ± 27.05	68.20 ± 30.25
	Control	52.46 ± 29.78	51.46 ± 28.80
Word chain	Proprioception-enhancing exercises	76.06 ± 7.94	83.53 ± 9.25
	Control	73.73 ± 8.83	72.20 ± 7.26
Rhyme test	Proprioception-enhancing exercises	87.33 ± 11.81	101.46 ± 13.74
	Control	84.80 ± 13.21	83.80 ± 14.69
Naming pictures	Proprioception-enhancing exercises	98.86 ± 16.55	113.40 ± 13.87
	Control	95.93 ± 18.99	94.46 ± 15.62
Text comprehension	Proprioception-enhancing exercises	80.46 ± 10.08	89.53 ± 7.63
	Control	77.26 ± 14.15	77.40 ± 13.30
Word comprehension	Proprioception-enhancing exercises	83.06 ± 15.93	110.00 ± 10.82
	Control	84.00 ± 16.89	83.53 ± 19.25
Elision	Proprioception-enhancing exercises	62.53 ± 9.14	70.46 ± 9.97
	Control	61.60 ± 6.15	61.40 ± 6.10
Reading non-words	Proprioception-enhancing exercises	74.53 ± 20.27	84.66 ± 18.23
	Control	70.06 ± 21.35	69.80 ± 20.39
Letter signs	Proprioception-enhancing exercises	89.20 ± 10.20	97.46 ± 9.98
	Control	86.60 ± 9.91	85.13 ± 10.56
Category signs	Proprioception-enhancing exercises	98.80 ± 10.05	116.33 ± 14.91
	Control	101.20 ± 19.46	100.06 ± 20.28
Dysgraphia	Proprioception-enhancing exercises	61.53 ± 17.05	77.83 ± 15.89
	Control	62.10 ± 19.86	60.93 ± 19.36

ANCOVA assumptions were examined before data analysis in order to ensure that the research data met these assumptions. The results of the Shapiro-Wilk test for the variables "dyslexia" (W=0.98, p=0.581) and "dysgraphia" (W=0.96, p=0.261) showed that the data follows a normal distribution. Levene's test was also used to examine the homogeneity of variances (to make sure that the variances of the experimental and the control groups were the same), and the results (F= 1.07, p= 0.31 for dyslexia and F= 3.12, p= 0.088 for dysgraphia) established the homogeneity of the variances. Therefore, it was possible to perform an analysis of covariance. After controlling the pretest effect, the experimental and control groups were compared in terms of posttest scores. Multivariate analysis of covariance (ANCOVA) was then performed to determine the effectiveness of proprioception-enhancing exercises in improving dyslexia and dysgraphia in students with SLD. The results of the posttest are presented in Table 4. As shown in Table 4,

there was a significant difference between the experimental and control groups in at least one of the dependent variables (p<0.01).

Table 4
The Results of Multivariate Analysis of Covariance on Posttest Scores of the Research Variables

Variable	Value	df	Error df	F	p	η^2
Pillais Trace	0.98	11	7	33.72	0.001	0.98
Wilks Lambda	0.02	11	7	33.72	0.001	0.98
Hotelling's Trace	52.99	11	7	33.72	0.001	0.98
Roy's Largest Root	52.99	11	7	33.72	0.001	0.98

Table 5 presents the results of the univariate ANCOVA for the posttest scores of the dependent variables. The F-values for the dependent variables showed that there was a significant difference between the experimental and control groups in the improvement of dyslexia and dysgraphia (p<0.01)). This means that the proprioception-enhancing exercises significantly improved dyslexia and dysgraphia in students with SLD.

Table 5
Results of One-way Analysis of Covariance on Research Variables in Experimental and Control Groups

Variables	SS	df	MS	F	P	η^2	Power
Reading words	860.62	1	860.62	17.40	0.001	0.61	0.98
Word chain	516.99	1	516.99	11.89	0.003	0.41	0.60
Rhyme test	1486.23	1	1486.23	28.63	0.001	0.63	0.99
Naming pictures	1763.78	1	1763.78	27.28	0.001	0.62	0.99
Text comprehension	617.06	1	617.06	59.81	0.001	0.78	1.00
Word comprehension	47.03.83	1	47.03.83	129.28	0.001	0.88	1.00
Elision	365.05	1	365.05	22.89	0.001	0.57	0.99
Reading non-words	735.63	1	735.63	20.72	0.001	0.55	0.99
Letter signs	566.18	1	566.18	14.95	0.001	0.47	0.95
Category signs	3329.38	1	3329.38	39.31	0.001	0.70	1.00
Dysgraphia	2063.81	1	2063.81	21.15	0.001	0.55	0.99

Discussion

The present study aimed to investigate the effectiveness of proprioception-enhancing exercises on dyslexia and dysgraphia in students with SLD in Ahvaz. The study findings showed that the proprioception-enhancing exercises were effective in improving dyslexia in students with SLD. This finding is consistent with the research results of previous studies (Faramarzi, 2020; Mahmoodi et al., 2019). The results obtained from the application of the independent variable (the proprioception-enhancing exercises) showed that these exercises improved the sensory profile of the participants in sensory exploration, emotional reaction, oral sensory sensitivity, attention/distraction, immobility, and subtle/perceptual movements (Ouellet et al., 2021). This indicates that the neural mechanism was more affected by the proprioception-enhancing exercises. Since sensory integration exercises basically focus on motor coordination and train children in motor skills, any training intervention that helps coordinate the senses can produce results similar to those of sensory integration exercises (Mahmoodi et al., 2019). Therefore, a reading improvement course (targeted at sensory coordination in reading) can reduce the reading errors of students with SLD.

The study results also indicated that the proprioception-enhancing exercises were effective in improving dysgraphia in students with SLD. This finding is consistent with the research results of previous studies (Faramarzi, 2020). Intervention program improved the sensory profile of the participants in sensory exploration, emotional reaction, low stamina/ tolerance, inattention/ distraction, subtle/perceptual movements, oral sensory sensitivity, poor registration, sensory sensitivity, and immobility. Studies have shown that sensory integration interventions can make positive

changes in some areas such as organizing, learning, attention, affection, exploratory behavior, circadian rhythm, sensory responsiveness, play skills, self-esteem, corresponding interaction, and family adjustment (Crasta et al., 2020). Furthermore, any movement coordination exercises that follow different principles and theories can improve dysgraphia.

Aman et al. (2014) reported that an intervention program with proprioception-enhancing exercises was effective in improving dysgraphia in both experimental groups compared to the control group (Aman et al., 2014). Kunhoth et al. (2022) studied the effects of an e-learning program based on the principles of face design on dysgraphia and showed that there was a significant relationship between the use of a web-based e-learning program and the academic progress of students in dictation and the related components (i.e., visual, auditory, and motor skills) (Kunhoth et al., 2022). The findings of Faghani et al. (2015) demonstrated the effectiveness of the process training and task-process training methods in improving the dictation problems of students (Faghani et al., 2015). However, they concluded that the task-process method was more effective than the process training one. Proprioception-enhancing exercises, which make changes in muscle strength, motor performance, and proprioceptive position sense in childhood, seem to be associated with poor body awareness and diagnosis of advanced coordination disorders. It can be hence stated that proprioception-enhancing exercises can increase coordination between the senses, reduce the symptoms of dyslexia and improve the sensory profile (Hashemi Malekshah et al., 2021).

A limitation of this study was that the education level and socioeconomic status of the families were not controlled. In addition, since the study population consisted of elementary school students in a specific age group in Ahvaz, the results should be cautiously generalized to students of higher education levels and also to elementary school students in other Iranian cities.

Conclusion

The study findings generally suggested that proprioception-enhancing exercises improved dyslexia and dysgraphia in students with SLD. The intervention program with proprioception-enhancing exercises implemented in this study was designed to address the learning needs of children with learning disabilities. This intervention included a set of motion exercises and competitive and exciting games to both maintain the motion effects of the program and encourage and motivate the children to continue the training sessions. As a result, this intervention managed to improve the reading and writing performance of the participants. It can hence be stated that purposeful, organized, and controlled proprioception-enhancing exercises are an alternative method to complementary therapy for improving the reading and writing performance of children with SLD. This intervention is recommended to be presented to the parents in family education classes. Future studies are recommended to test this intervention on other groups of children with special needs and larger samples. In addition, future studies are recommended to investigate the moderating role of gender on the research variables to compare the effects of this intervention on male and female students with SLD.

Conflicts of Interest

No conflicts of interest declared.

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