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ORIGINAL RESEARCH

Effectiveness of computer-based cognitive rehabilitation on sensory profile, balance, and academic achievement of children with mild intellectual disabilities

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Abstract

Objective: Children with intellectual disabilities (IDs) have deficits in sensory profile, balance, and academic achievement, which diminishes their adaptive functioning. The present study aimed to investigate the effects of computer-based cognitive rehabilitation on sensory profile, balance, and academic achievement of children with mild IDs.

Materials and Methods: This was a quasi-experimental study with a pre-test-post-test design and a control group. The statistical population comprised all the elementary school students with mild IDs aged 7-11 years in Shiraz (Iran) in 2021-2022. A sample of 30 students was purposively selected and divided into two groups: a computer-based cognitive rehabilitation group and a control group (15 students per group). To collect data, the sensory profile, static and dynamic balance tests, and academic achievement were used. The data were analyzed using the analysis of covariance (ANCOVA) in SPSS v. 24.

Results: There was a significant difference between the children with mild IDs in the computer-based cognitive rehabilitation and control groups in the sensory profile, balance, and academic achievement ($P<0.01$).

Conclusion: Given that computer-based cognitive rehabilitation improved the sensory profile, balance, and academic achievement of children with mild IDs, parents and teachers are advised to use this method to enhance these children's abilities in the mentioned domains.

Keywords: Cognitive training, Rehabilitation, Sensory profile, Balance, Intellectual disability, Children

Introduction

Intellectual disabilities (IDs) are long-term physiological disorders that significantly impact children's ability to participate in daily life activities, such as independent feeding, communication, and mobility (1). Not all people with IDs show mental or intellectual disability with the same conditions, severity, causes, or effects (2). Educationally, children with IDs are divided into three groups: educable, trainable, and supportable (3). In Iran, the Exceptional Education Organization is in charge of teaching teachable students with IDs. In this group of students, rehabilitation aims to maximally actualize their potential, create occupational and professional competence, and foster personal and social skills (4, 5). According to the latest Diagnostic and Statistical Manual of Mental Disorders (DSM) definition, IDs begin during the developmental period and are associated with deficits in intellectual performance and adaptive skills in conceptual, social, and practical spheres (6).

Children with IDs show sensory profile deficits. The sensory profile includes sensory seeking, emotional reaction, oral sensitivity, inattention/distraction, immobility, and fine motor/perceptual skills (7). The sensory profile generally refers to how the central and peripheral nervous systems manage sensory information. It is an inseparable part of children's environmental experience and initiates learning (8). Receiving, regulating, and integrating sensory information successively produces an adaptive response. Children's involvement in activities (behavioral response to sensory stimuli during normal daily activities) and learning at home, school, and play settings requires full attention and awareness of all the senses and recognition of affects caused by a particular experience (9). Behavior is shaped in association with neurological processes; the sensory profile in the brain becomes specialized with the development of nerve centers, and maladaptive behavior is the outcome of non-organizing processing (10).

Children with IDs also show developmental coordination disorder (DCD) in physical fitness domains, including coordination and balance (11). Children with motor balance problems will also have trouble learning motor skills. Body posture control for stability and awareness requires perception (integrating sensory information to recognize and assess the body's position and movement in space) and action (generating forces to control body posture systems). Musculoskeletal components include the joints' range of motion, spinal flexibility, muscle characteristics, and biomechanical relationships between different body parts (12, 13). These characteristics show a developmental delay in some children without any particular medical, environmental, or intellectual etiology (14). These children also show problems with sitting and standing unaided; walking too slowly; experiencing frequent falls; and having trouble holding a pencil, drawing, paying attention, concentrating, recalling, and riding a bicycle (15).

Children with IDs face many problems in learning due to cognitive differences with their typically developing peers (16). Meanwhile, identifying their characteristics and using appropriate solutions will improve their education and academic achievement (17). On the other hand, not knowing their characteristics and not applying suitable motivational methods will lead to their academic underachievement (18). Nader-Grosbois (19) found a significant difference in self-handicapping between typically developing and intellectually disabled students. Accordingly, there are differences between typically developing and intellectually disabled children in self-handicapping and academic achievement.

The impaired execution of coordinated movements, sensory profile, balance, reaction time, and academic achievement among children with mild intellectual disabilities has been a persistent concern for parents, teachers, as well as motor and rehabilitation researchers. As a result, numerous interventions have been administered to improve or, at least, alleviate these symptoms in children with IDs (15). An effective therapy for mild IDs involves the rehabilitation of cognitive deficits (20). Cognitive rehabilitation can be defined as systematic performance-based cognitive therapy relying on evaluating and understanding cerebral-behavioral deficits (21). This therapy uses the following techniques to bring about functional changes: stabilizing, reinforcing, and rebuilding acquired behavioral patterns, consolidating new patterns, cognitive activity, and compensating for the activity of

the damaged nervous system (22). Cognitive rehabilitation is a method to restore lost cognitive capacities through certain tasks and targeted stimuli. It aims to improve the individual's performance in carrying out tasks (23). In this method, the therapist considers the information obtained from evaluating the sessions and, accordingly, designs tasks to reinforce the brain's cognitive functions. The therapist increases the task's difficulty level with the client's progress (24). Recently, significant progress has been made in using computers in cognitive sciences for treatment. Cognitive rehabilitation programs are commonly offered as computer-based tasks to improve cognitive deficits (25).

Poor motor functioning and physical fitness due to a lack of continuous effort and training reduces children's self-esteem and, as a result, participation, which further diminishes their motor functioning and physical fitness. Considering the poor motor skills of children with IDs and the importance of these skills, and given that physical activities promote physical health, intellectual performance, perception of behavior and emotions, and personality, physical exercises may offer numerous benefits for these children. Based on these children's problems, their motor development seems to merit more studies. Besides, effective methods to solve the problems of children with IDs have received little research attention. Accordingly, the present study aimed to investigate the effectiveness of computer-based cognitive rehabilitation on sensory profile, balance, and academic achievement of children with mild IDs.

Materials and Methods

This was a quasi-experimental study with a pre-test-post-test design and a control group. The statistical population comprised all elementary school children with mild IDs aged 7 to 11 years in Shiraz (Iran) in the 2021-2022 academic year. The sample was selected purposively. The sample size was estimated at 15 students per group using Cohen's formula, with an effect size of 0.05, and based on the effect sizes of previous studies (26). The students were randomly assigned to two groups: computer-based cognitive rehabilitation and a control group (15 students each). Students who were diagnosed with mild IDs by a psychologist based on the DSM-5 criteria, who did not have any other disorder, and whose parents provided written consent for their participation in the research were included. The exclusion criteria were not providing consent for participation, receiving a treatment plan simultaneously, missing the therapy sessions, and not filling out the questionnaires.

Instruments

The sensory profile: Dunn et al.'s Sensory Profile was administered to assess the effects of sensory information on the children's performance. This profile includes 124 items and is completed by parents. The items are scored on a five-point Likert scale from 0 (almost never) to 100 (almost always) (27). Mirzakhani et al. (28) reported the total Cronbach's alpha coefficients of the Persian version of the sensory profile to be 0.79.

Static and dynamic balance tests: In the stork test (static balance), the child stands on one leg on a flat surface. The free leg is bent at the knee. Both arms remain beside the body and can move freely. The examiner measures the maximum time the child stands on his/her foot using a timer, which is stopped when he/she places the free foot on the ground. This test is performed twice for both feet, and the best result (maximum time) is recorded. The tandem gait test (dynamic balance) assesses the child's ability to walk in a straight line. The child is asked to take 15 steps in a straight line; each step is taken such that the heel of the moving foot touches the toe of the standing foot. The maximum score is 15. If the child deviates from the line before finishing the 15 steps, the test is stopped, and the number of steps taken is recorded. This test is performed twice, and the best score is recorded (29).

Academic achievement: The children's grade point averages (GPAs) of the first and second semesters were compared as a measure of their academic achievement.

Intervention

Computer-based cognitive rehabilitation: Cognitive rehabilitation was administered using the cognitive rehabilitation software Captain's Log MindPower Builder v. 14. This training set is used to improve higher-order cognitive functions and processes. It comprises 2000 programs and tasks at different difficulty

levels to improve various cognitive functions. It is based on working memory and central processing speed and, thus, includes basic and higher-order cognitive skills. This program is designed for 5 years of age and older. Sandford (30), one of the main developers of this cognitive training system, first designed the visual attention training program and then the listening tasks. The rehabilitation was administered in twelve 50-minute individual sessions twice a week. This software is developed based on extensive cognitive and educational research and includes 50 programs at multiple difficulty levels, organized as training sets (for attention skills, memory skills, problem-solving, working memory, sensory processing, and balance) within the system. In this study, the students were trained using this software.

Data Analysis

The data were analyzed with descriptive (mean and standard deviation) and inferential statistics, namely the analysis of covariance (ANCOVA), in SPSS v. 24, at the significance level of < 0.05.

Results

The participants included 30 children with mild IDs with an average age of 9.27±2.62 years. According to Table 1, the mean scores of sensory profile, balance, and academic achievement significantly changed on the post-test compared to the pre-test in children with mild IDs in the computer-based cognitive rehabilitation intervention group. These changes confirm that the experimental group's post-test scores of sensory profile, balance, and academic achievement increased. However, the pre-test scores of the control group did not significantly change on the post-test.

Table 1. Mean and standard deviation (±SD) of the research variables in intervention and control groups

Variables	Phases	Computer-based cognitive rehabilitation group	Control group
		Mean ± SD	Mean ± SD
Sensory profile	Pretest	2008.33 ± 67.25	1978.33 ± 83.38
	Posttest	5061.67 ± 338.44	1971.67 ± 61.86
Balance	Pretest	11.47 ± 1.12	12.33 ± 1.75
	Posttest	29.20 ± 1.65	13.13 ± 1.45
Academic achievement	Pretest	11.33 ± 0.98	11.07 ± 1.03
	Posttest	15.53 ± 0.52	11.53 ± 0.99

Before performing the ANCOVA, its statistical assumptions were checked using Levene's test (for the equality of variances of the two groups) and the Kolmogorov-Smirnov test (for the normal distribution of data). The assumptions of the ANCOVA were met based on the results of these tests.

Based on Table 2, the F ratio of ANCOVA for sensory profile, balance, and academic achievement indicated a significant difference between the two groups. Therefore, the computer-based cognitive rehabilitation program significantly improved the sensory profile of children with mild IDs compared to the control group. In other words, this program had a positive effect on enhancing the students' sensory profile. Moreover, the rehabilitation program significantly increased the balance of children with mild IDs compared to the control group. The computer-based cognitive rehabilitation program also improved the academic achievement of children with mild IDs compared to the control group; in other words, it significantly improved the academic achievement of the experimental group.

Table 2. Results of analysis of covariance on research variables in intervention and control groups

Variables	SS	df	MS	F	P	η^2	Power
Sensory profile	82418213.01	1	82418213.01	616.67	0.001	0.96	1.00
Balance	2690.06	1	2690.06	677.79	0.001	0.97	1.00
Academic achievement	22.80	1	22.80	6.14	0.022	0.22	0.86

Discussion

This study aimed to investigate the effects of computer-based cognitive rehabilitation on sensory profile, balance, and academic achievement of children with mild IDs. Based on the findings, the computer-based cognitive rehabilitation treatment significantly affected the sensory profile, balance, and academic achievement of children with mild IDs. The brain is a dynamic system with an extensive neurological reorganization capacity. Behavioral changes are rooted in structural alterations in the brain, especially in dendritic and synaptic fibers. Cognitive abilities can often be improved. Structured stimulation of experiences for the brain is associated with improved behavioral function of neurons. Functional reconstruction commonly involves using regions close to the damage site and similar regions in the other hemisphere. Behavioral outcomes reflect the complex interaction of bottom-up and top-down processes and intra- and inter-hemispheric effects (31). Consequently, the significant improvements in the executive functions of children with IDs following the cognitive rehabilitation program are due to the improved neural plasticity of their brains; this can be checked by measuring the brain serum level of the brain-derived neurotrophic factor (BDNF) before and after cognitive rehabilitation. Kesler et al. (32) reported that cognitive rehabilitation restores the neurons responsible for the sensory profile in children's brains. According to

Jalilvand et al. (33), cognitive rehabilitation through computer games improved the sensory profile, response inhibition, and sustained, focused, and selective attention in children with attention-deficit/hyperactivity disorder (ADHD). Computer-based cognitive rehabilitation therapy targets several cognitive functions and the five senses in an attractive set of games, so it can be used as an effective treatment to improve the balance of children with IDs.

Software development to treat different disorders and diseases is an important modern development that can turn older and more expensive methods into simple and precise processes, leading to better progress. According to the principle of brain plasticity and self-repair, computer-assisted cognitive rehabilitation creates stable synaptic changes in the less active regions of the brain by successively stimulating them. The task's difficulty level can be adjusted from simple to difficult based on individual differences to create continuous cognitive challenges for the client. According to Deng et al. (34), an important point considered by many modern computer games is the purposeful nature of these games. Since computer games challenge people's skills such as precision, reaction speed, and problem-solving, they can improve academic achievement in people who have problems with attention, precision, or problem-solving problems. Computer-based cognitive training programs provide tools to help promote the basic mental processes crucial to higher-order learning. Computer games enhance academic achievement because a significant amount of cognitive energy is required to complete the game. According to Georgopoulou et al. (35), computer-based cognitive rehabilitation combined with traditional education proves more influential on academic achievement than traditional paper-and-pencil training alone. In computer-based programs, the task's difficulty level is determined based on the person's initial readiness and can be gradually increased based on his/her achievement.

This study was limited by the lack of follow-up (due to the lack of long-term access to the sample) and the generalizability of the results. The effectiveness of this program should be checked on other groups of children with behavioral and learning disorders so that the results can be generalized, and a comprehensive protocol can be developed.

The computer-based cognitive rehabilitation program effectively enhanced the sensory profile, balance, and academic achievement of children with mild IDs. Therefore, cognitive rehabilitation therapy based on computer games, targeting several cognitive functions and the five senses in attractive games, is an effective and persistent therapy for improving the sensory profile, balance, and academic performance of children with IDs. According to the findings, parents and teachers are advised to use this method to enhance these children's abilities in the mentioned domains.

Ethical Considerations

The study was approved by the Ethical Committee of Islamic Azad University- Ahvaz Branch (code: IR.IAU.AHVAZ.REC.1400.033).

Conflict of interest

Author declares no conflict of interest.

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