

Cognitive-assisted rehabilitation in improving information processing and problem-solving in Down syndrome patients

Abstract

The present study aims to evaluate the effectiveness of computer-assisted cognitive rehabilitation in improving information processing and problem-solving in people with Down syndrome. The present study is experimental research with a single-subject design with multiple baselines. In the present study, there are three types of baselines, including 3-week, 5-week, and 7-week baselines. Nine clients are placed in these three types of baselines as shown in Figures 3-3, and after the end of the baseline, they enter the treatment. The effectiveness of treatment for each person is compared to his or her baseline and other people. The statistical population of the study included all 16 female and male Down syndrome students who studied in exceptional schools of Delfan city and Nazarzadeh exceptional school of Khoramabad city in the academic year of 2013-2014. Among these 16 students, 9 people were selected as a sample using a convenience sampling method. To examine and measure cognitive variables, Wechsler intelligence tests (forward digit span and backward digit span), Tower of London, continuous performance, Stroop, and Corsi block-tapping tests were assessed. To examine and analyze the behavioral data, the visual analysis method, Cohen's *d* size, recovery percentage (in cases where the goal is to increase behavior), and average reduction percentage (in cases where the goal is to decrease behavior) were used in this research. The results indicate the effectiveness of cognitive rehabilitation in improving cognitive deficits (problem-solving, information processing) of children and adolescents with Down syndrome.

Keywords: *Down Syndrome patients, Effectiveness of cognitive rehabilitation, Information processing, Problem-solving*

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Introduction

Down syndrome is one of 750 to 1000 genetic disorders that cause mental and intellectual disability (Seguin, 1846). It is the most common mental retardation and has been proven in numerous studies and various analyses. If early interventions are used during the first 6 years of life with EI early intervention programs, the results will be almost optimistic (Guralinck, 1998). This disease imposes a great burden on the family and society, and appropriate interventions can reduce costs and make the person productive. Thus, there is a great demand for new and effective treatments from the family and society. Since 1990, a great number of studies have been conducted on children with DS, and the methods of developing interventions and treatment strategies for them were set (Dunst, 1988, 1998, Candel and Carranza 1993, Spiker and Hampan 1997). If cognitive interventions are performed in preschool age until early adolescence, the improvement of cognitive defects will be recovered and the results will be promising (Silva, Ehninger 2009). Cognitive interventions are a prerequisite for another group of interventions, and this issue makes the work on cognitive variables more necessary. Occupational therapy and rehabilitation are the only effective and documented treatments that therapists use to treat Down syndrome. Experimental studies have consistently shown that these treatments can reduce disruptive behaviors to a limited extent and improve the physical condition of children and adolescents with this.

However, it should be noted that none of the medical and therapeutic interventions directly target the cognitive problems associated with Down syndrome. One of the promising treatments used successfully in disorders of brain damage, schizophrenia, hyperactivity, speech disorders, MS, Alzheimer's, and brain atrophy caused by dementia is cognitive rehabilitation therapy. This therapy tries to restore the brain's memory, attention, language learning, decision-making, planning, problem-solving, and executive functions

Information processing: all information collected by our body and senses is sent to the brain to be identified, classified, and stored with the help of brain processes and used when necessary. These steps are repeated in our brains throughout the day. The information processing process helps people to complete all their daily activities. Even doing our smallest daily activities requires information processing processes. Problem-solving, which is considered the most complex part of any intellectual operation, is defined as an important cognitive process that requires the integration and control of a series of basic and ordinary skills. Problem-solving occurs when a living being or an artificial intelligence system does not know what path to take to go from one position to another. This is also a part of the process of a bigger problem, which finding the problem and shaping the problem is a part of it. Problem-solving, which is considered the most complex part of any intellectual operation, is defined as an important cognitive process that requires the integration and control of a series of

basic and ordinary skills (Monari Martinez, & Pellegrini, 2010).

Cognitive rehabilitation is a complex set of ten design techniques to improve perception, attention, understanding, learning to remember, problem-solving, and reasoning in people who have lesions in these areas. Cognitive rehabilitation therapy (CRT) is the art and science of restoring these mental processes and teaching compensatory strategies. Given what was stated above, the present study aims to evaluate the effectiveness of computer-assisted cognitive rehabilitation in improving information processing and problem-solving for Down syndrome patients.

Methods

The present study is experimental research with single-subject with multiple baselines. In the present study, there are three types of baselines, including 3-week, 5-week, and 7-week baselines. Nine clients are placed in these three types of baselines as shown in Figures 3-3, and after the end of the baseline, they enter the treatment. The effectiveness of treatment for each person is compared to his or her baseline and to other people. The statistical population of the study included all 16 female and male Down syndrome students who studied in exceptional schools of Delfan city and Nazarzadeh exceptional school of Khoramabad city in the academic year of 2013-2014. Among these 16 students, 9 people were selected as a sample using a convenience sampling method. The age range of samples was 9-17 years. To identify the Down syndrome disorder and the absence of psychotic and organic disorders and generally meeting the criteria and not meeting the exclusion criteria, the medical records of the clients were studied. In addition, to rule out hearing and ergonomic problems, the subject's medical history was also asked by the school counselor and the mother of the subject. Kessler's test was conducted by a clinical psychologist to determine the range of intelligence.

Research tools

1- Cogniplus software

This software was developed for training cognitive functions by Schuhfried in 2006 and uses the multimedia approach. In this software, clients are asked to apply what they have learned in their daily life. This software has sections for working memory functions, sustained attention, continuous attention, information processing, problem-solving and selective attention.

2- Forward digit span

The tester reads a set of single-digit numbers randomly and the subject repeats the numbers in the same order. The series of numbers initially has two digits and after each presentation, one digit is added to the chain of numbers until it reaches a maximum of seven digits. The test is stopped when the child repeats a chain incorrectly twice in a row. No feedback is given to the child during the test. Performance is scored as the total number of correctly recalled series.

3-Backward digit span

The method of performing this test is the same as the forward digit span test, with the exception that the child must remember the digits in the reverse order of their presentation. The test is scored as the number of correct recalls. This test has been successfully used in 6-7 years of old children and even in 4 years of old children. It has a high correlation with central executive scales and its test-retest reliability has been reported at 0.62.

4-Stroop computer test

The Stroop task is a classic laboratory model for assessing selective attention. This test assesses selective attention, or the capacity to pay attention to features of a stimulus and ignore task-irrelevant features. This test has two sections:

The first section consists of the computer presentation of four colors (yellow, red, blue, and green) in the form of a loop. Fifty colored loops are presented, randomly presented for each of the four colors (yellow, red, blue, and green). Each loop appears indefinitely. The subject's task is to press the same color of the loop displayed on the computer keyboard. The goal is to find out if the client can recognize colors and can read.

In the second section: words with the consonant and non-consonant colors are presented. A total of 48 words that are consonant with color and 48 words that are not consonant with color are presented randomly (yellow, red, blue, and green) for 2 seconds on the computer screen. The distance between two stimuli is 800 thousandths of a second.

The subject's task is to pay attention only to the color of the word, regardless of the meaning of the words. For example, the word blue is written in green and the subject must press the green key. In scoring this test, the subject's reaction time, the number of color naming errors (error announcement) and omission for both types of consonant and incongruent stimuli, and the interference score are calculated. Siegest reported the test-retest reliability of the reaction time for the third section at 0.86. Cox et al. found a high correlation between the Stroop test and tests that assess response inhibition.

5- Continuous performance test

It is known as the most common laboratory tool in the measurement of care and is widely used in the assessment of hyperactivity with attention deficit. It is prepared for therapeutic and research purposes and in all forms, the subject must pay attention to a relatively simple set of visual or auditory stimuli and give his or her response when the target stimulus appears by pressing a key. In most recent studies, visual stimuli are presented for a short time on the computer screen and the subject must respond to the target stimulus by pressing one of the keys on the keyboard. In this test form, there are 150 Persian numbers or images as stimuli in the Persian form of the test, and 30 stimuli (20%) are considered target stimuli, and the remaining 80% as non-target stimuli. The duration of presentation of each stimulus is 200 thousandths of a second and the interval between 2 stimuli is one second. The duration of the test by considering the training stage for a better understanding of the subject before the main stage is 200 seconds.

In this test, two types, including the error of omission and error of commission are scored. An error of omission occurs when a subject fails to respond to the target stimulus and indicates that the subject has difficulty understanding the stimulus. This type of error is interpreted as a problem in the sustainability of attention and indicates a lack of attention to the stimuli. An error of commission occurs when the subject responds to a non-target stimulus. This type of response indicates a weakness in impulse inhibition and is interpreted as a problem in impulse control or impulsivity. In this test, these two types of errors are counted by the computer program. In addition, the number of correct responses and the subject's reaction time to the stimulus is also calculated. According to the results of the study conducted by Hadianfard et al, it was found that the Persian form of the Continuous Performance Test (CPT) has good validity and reliability. In their study, the reliability coefficient (Test-Retest) of different sections of the test was between 52% and 93%. The validity of the test was examined by criterion validity on the normal group (30 primary school boys) and the ADHD group (25 primary school boys). Statistical comparison of the mean of the two groups in different sections of the test showed a significant difference between the performances of these two groups ($p < 0.001$). The results of this study are in line with those of previous studies conducted in other countries.

6- Tower of London test

This test is one of the important tools for understanding the action of planning and organizing (Krirkorian et al., 1994, Lezak et al., 2004). Since the performing of this test by computer could have many advantages, including accuracy in execution, accurate measurement of the results, including the number of correct and incorrect items, as well as accurate time

measurement of the steps, the initial version of this test in computer was prepared based on the Delphi programming language at the Sinai Behavioral-Cognitive Sciences Research Institute. The goal of this test is for the subject to use his or her maximum ability and achieve the best performance quickly. Before performing the test, one's skill in using the computer mouse must be ensured. The purpose of this test for the subject is to use his or her maximum ability and achieve the best performance quickly. In this test, the person must make the shape of the sample by moving the colored beads (green, blue, and red) and placing them in the right place with the minimum necessary movements. People who perform successfully in this test can solve problems, plan, evaluate, and make high decisions within the specified time. The time required to perform this test is between 11 and 16 minutes. A correlation of $r = 0.41$ has been reported between the results of this test and the Porteus maze test (Culbertson and Zillmer, 1998; Krirkorian et al., 1994). The validity of this test has been reported at an acceptable level of 0.79 (Lezak et al., 2004).

Corsi block-tapping test

It is a computer test where there is a screen with 9 dark rectangles on it. The flash is lit on each of the rectangles. After a few seconds, the subject must light the same rectangles. First, two rectangles are lit. Then, an additional rectangle is added in each presentation to reach 6. The test ends if the subject lights the series of rectangles twice. Performance is the total number of correctly recalled series. The test-retest validity of the Corsi test is 0.53, which is usually used as the visual-spatial span of working memory.

Research implementation method

First, a diagnostic interview was conducted with the students by a psychiatrist to identify the Down syndrome disorder and the absence of psychotic and organic disorders. Wechsler test for children was performed by clinical psychologists to determine the range of intelligence. Male and female students diagnosed with Down syndrome who did not meet the exclusion criteria were placed in different baseline conditions. Clients were placed 3 by 3 in three types of baselines of 3, 5, and 7 measurement points of dependent variables. The subjects in three types of baselines were selected randomly. In each baseline, the working memory variable score was obtained by calculating the scores obtained in the subscales of forwarding digit span and backward digit span.

The problem-solving test was recorded by the Tower of London test score. The variable of selective attention was calculated by the number of errors and responses to omit consonant and incongruent stimuli in the Stroop test. Accordingly, in the baselines for continuous attention and

information processing, the continuous performance of the subjects was recorded by the score of the computer test. Then, the subjects entered the design with different baselines. Accordingly, the first, second, and third subjects entered the treatment after three measurement points of the dependent variable, the fourth, fifth, and sixth subjects after five measurement points of the dependent variables, and the seventh, eighth, and ninth subjects entered the treatment after seven measurement points of the dependent variables. The number of intervention sessions was 20 sessions of 45 minutes. One month after the end of the treatment, the score of the dependent variables of the subjects was collected again.

Treatment process

The first group of subjects received the following treatments in the first session. After the tenth treatment session, the subjects were re-assessed, and then from sessions 11 to 15, in addition to the four tasks of attention (continuous, focused, selective, and sustained), motor-visual and memory tasks were added to them. After Session 15, the subjects were tested with Stroop, continuous performance, Corsi block-tapping, digit span, and Tower of London tests. In Sessions 15 to 20, all the above tests were performed on the subjects. After Session 20, the subject was re-assessed and after one week, they were followed up using Stroop, continuous performance, Corsi block-tapping, digit span, and Tower of London tests.

The second group: When the subjects of the first group entered the treatment, the second group was still assessed. In the Session 3 of treatment of the first group, the second group entered the treatment after 5 sessions of evaluation. The treatment process and tasks were the same as in the first group, and the evaluations were done after sessions 5, 10, 15, and 20. After one week, the follow-up was done using Stroop tests, continuous performance, Corsi block-tapping, digit span, and Tower of London tests.

The third group: When the subjects of the first and second groups entered the treatment, the third group was still assessed. In the Session 7 of the first group and Session 5 of the second group, the third group entered the treatment after 7 evaluation sessions. The treatment process and tasks were the same as in the first and second groups, and the evaluations were done after sessions 5, 10, 15, and 20. After one week, the follow-up was done using Stroop tests, continuous performance, Corsi block-tapping, digit span, and Tower of London tests. It should be

noted that at the beginning of each training program, necessary explanations were given to the subjects.

Computer-assisted cognitive rehabilitation treatment package

Cognitive rehabilitation was done by Cogniplus software. In this software, clients were asked to apply what they have learned in daily life in training. The rehabilitation training took place in 20 45-minute sessions three times per week. Different images are presented one after the other. In levels 1 to 3, the subject must compare each image with the previous image, if it is repeated, he or she must press the confirmation key, and if it is not similar to the previous image, he or she must press the Ctrl key. From level 3 onwards, different images are presented one after the other and the subject has to compare the current image with the previous two images. To examine and analyze the behavioral data, the visual analysis method, Cohen's d size, recovery percentage (in cases where the goal is to increase behavior), and average reduction percentage (in cases where the goal is to decrease behavior) were used in this research.

Results

Visual analysis of the graph can examine the variation in the intensity of symptoms based on three methods (level, slope, or trend of variability). Graph 1 and Table 1 show that in group 1, three baselines were recorded for the highly variable subjects. Variability in scores is often observed in the intervention stage, and in the follow-up stage, the created level remains relatively constant. As seen, when the first group entered the treatment, the second and third groups are still in the baseline stage, and when the variations in the first group begin, there is no variation in scores in the other two groups. The variation in the level in all three groups began after entering the treatment, and the variations before that were not at the level of variations that are specific to children with Down syndrome. Out of 9 studied cases, all cases had an increase in the total score during the treatment period. This increase in score has been shown since the initial sessions. The percentage of the interference score and the effect size was high for all cases. In all nine cases, we observe a sharp slope in the mean score in the initial sessions. As the sessions increase, we observe that this slope reaches a balanced level without fluctuations. In all nine cases, the percentage of recovery is above 100%, thus the fourth hypothesis is confirmed. The details of the analysis of the above cases are as follows:

ازودنی: subject

پیگیری: follow-up

خط پایه: baseline

نرمال: normal

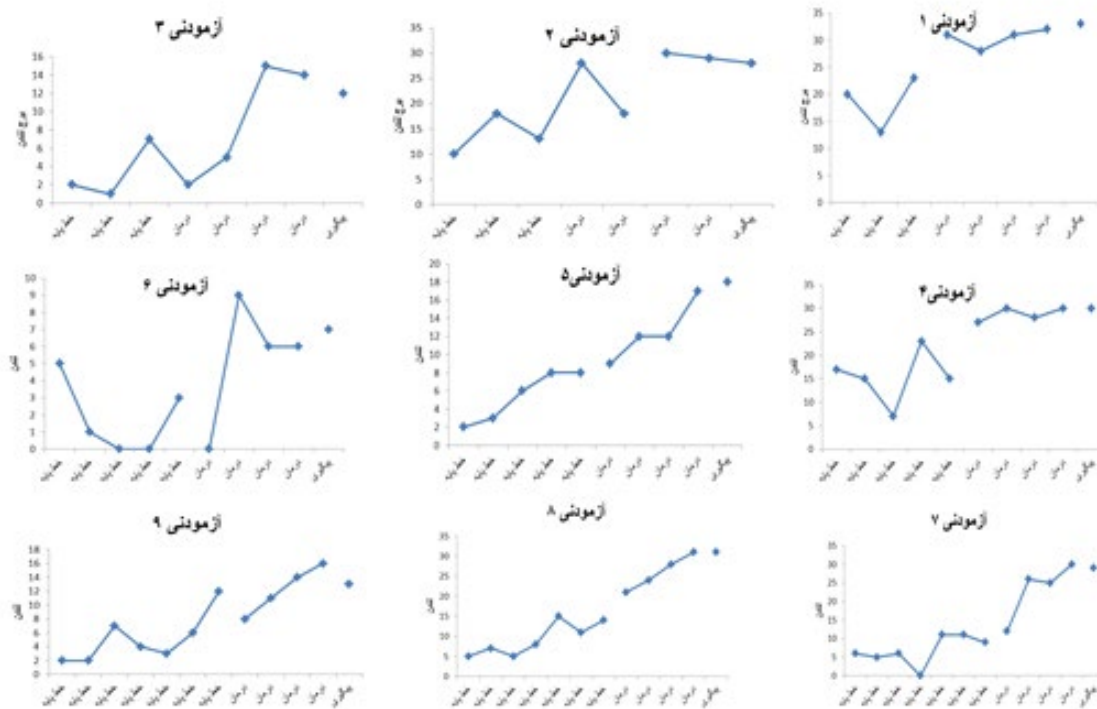


Table 1: (Tower of London)

London	Subject 1	Subject 2	Subject 3
MPI	39	48	63
MPR	63	92	170
D	1.8	1.67	1.06
	Subject 4	Subject 5	Subject 6
MPI	46	57	66
MPR	87	131	192
D	1.73	1.6	1.1
	Subject 17	Subject 8	Subject 9
MPI	71	64	58
MPR	239	180	138
D	1.76	1.88	1.51

As seen, in Subject 1, the experimental application has affected the performance of problem-solving. The effect size indicated

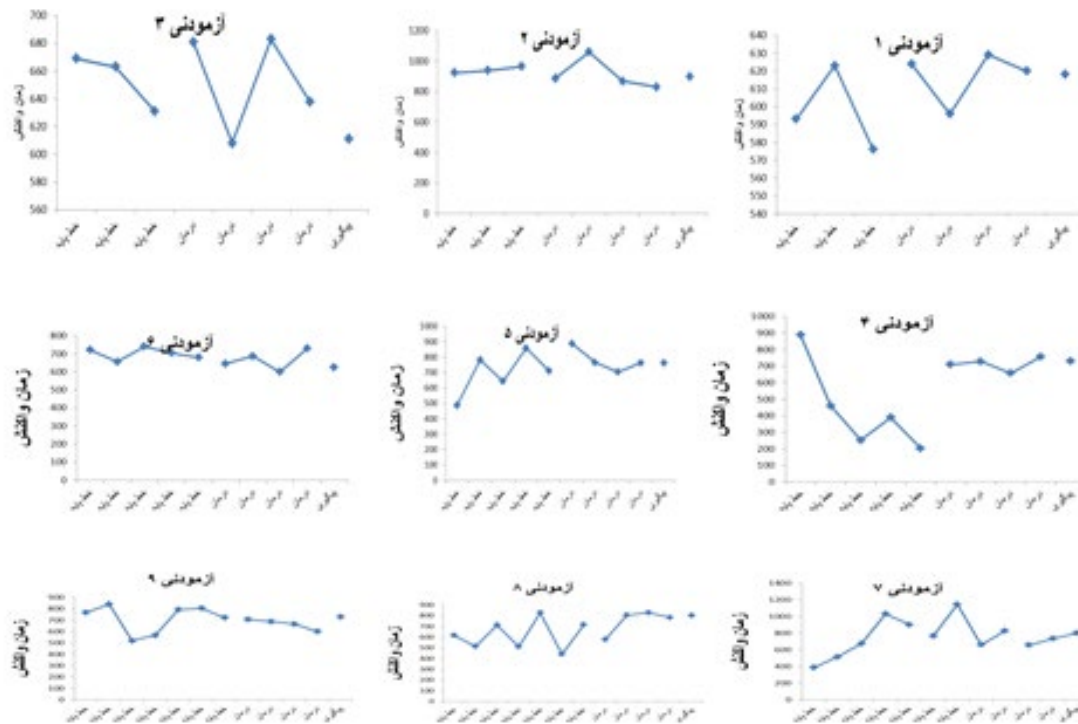
that problem-solving improved by about 1.8 compared to baseline. The percentage of improvement in problem-solving compared to baseline in Subject 1 is 63%. In Subject 2, the

experimental application has affected the performance of problem-solving. The effect size indicated that problem-solving improved by about 1.7 compared to baseline. The percentage of improvement in problem-solving compared to baseline in Subject 2 is 92%. In Subject 3, the experimental application has affected the performance of problem-solving. Effect sizes show that problem solving improved by about 16 compared to baseline. The percentage of improvement in problem-solving in Subject 3 compared to the baseline is 170%. In subject 4, the experimental application has affected the performance of problem-solving. The effect size indicated that problem-solving improved by about 1.8 compared to baseline. The percentage of improvement in problem-solving in Subject 4 compared to the baseline is 87%. In Subject 5, the experimental application has affected the performance of problem-solving. Effect sizes show that problem solving improved by about 16 compared to baseline. The percentage of improvement in problem-solving in Subject 5 compared to baseline is 131% (Table 1). In subject 6, the experimental application has affected the performance of problem-solving. The effect size showed that problem solving improved by about 1.1 compared to baseline. The percentage of improvement in problem-solving in Subject 6 compared to the baseline is 192%. In Subject 7, the experimental application has affected the performance of problem-solving. The effect size showed that problem solving improved by about 1.8 compared to baseline. The percentage of improvement in problem-solving in Subject 1 compared to baseline is 239%. In Subject 8, the experimental application has affected the performance of problem-solving. The effect size showed that problem solving improved by about 1.9 compared to baseline. The percentage of improvement in problem-solving in Subject 8 compared to baseline is 180%. In Subject 9, the experimental application has affected the performance of problem-solving. The effect size showed that problem solving improved by

about 1.5 compared to baseline. The percentage of improvement in problem-solving in Subject 9 compared to baseline is 138%.

The visual analysis of the graph shows the variation in the intensity of the symptoms at three procedures (level, slope, or trend of variability). Graphs 1, 2, and 3 show that three baselines have been recorded for the subjects in group 1, and the variability in them is very high. Variability in scores is often observed in the intervention stage, and in the follow-up stage, the created level remains relatively constant. As shown, when the first group entered the treatment, the second and third groups are still in the baseline stage, and when the variations in the first group begin, there is no variation in scores in the other two groups. The variation in the level in all three groups began after entering the treatment, and before that, the variations were not at the level of variations that are specific to children with Down syndrome. Out of 9 studied cases, all cases had a decrease in reaction time variables during the treatment period. They have shown a reduction in reaction time from their initial sessions. The effect size was large for all cases and the percentage of reduction in reaction time was moderate (Table 2).

In all nine cases, we do not observe a straight slope of decrease in the rate of correct reaction time in the initial sessions. However, with increasing treatment sessions, we observe a straight slope in the reduction of reaction time. This issue is related to the variability of attention in people with Down syndrome. However, with increasing sessions, we observe that this slope reaches a balanced level without fluctuations. Among the nine cases, the fourth case has a higher percentage of improvement (69%) than other cases, thus the fifth hypothesis is confirmed. The details of the analysis of the above cases are as follows:



Graph 2: Variation in intensity of symptoms based on three procedures

Table 2: (reaction time)

Subject 1	correct	Reaction time
MPI	6	3
MPR	7	3
D	1.78	1.06
Subject 2		
MPI	1	3
MPR	1	3
D	-0.26	-0.43
Subject 3		
MPI	5	-
MPR	5	-
D	1.81	-0.07
Subject 4		
MPI	12	38
MPR	14	62
D	1.48	1.2
Subject 5		
MPI	27	11
MPR	38	12
D	1.91	0.74
Subject 6		
MPI	14	5
MPR	17	5

D	1.62	-0.83
Subject 7		
MPI	19	8
MPR	23	7
D	1.33	-0.26
Subject 8		
MPI	14	17
MPR	17	21
D	1.42	0.96
Subject 9		
MPI	20	8
MPR	25	7
D	1.78	-0.52

As seen in Subject 1, the experimental application has affected the performance of information processing. The effect size indicates that information processing improved by about 1 compared to baseline. The percentage of direct improvement compared to the baseline in Subject 1 is 3%. In Subject 2, the experimental application has affected the performance of information processing. The effect size indicated that information processing improved by about 0.43 compared to baseline. The percentage of direct improvement in Subject 2 compared to the baseline is 3%. In Subject 3, the experimental application has affected the performance of information processing. The effect size indicated that information processing improved by about 0.7 compared to baseline. The percentage of direct improvement in Subject 3 compared to the baseline was not calculable.

In Subject 4, the experimental application has affected the performance of information processing. The effect size shows that information processing improved by about 1 compared to baseline. The percentage of direct improvement in Subject 4 compared to the baseline is 62%. In Subject 5, the experimental application has affected the performance of information processing. The effect size showed that problem solving improved by about 0.74 compared to baseline. The percentage of direct improvement in Subject 5 compared to the baseline is 12%. In Subject 6, the experimental application has affected the performance of information processing. The effect size showed that problem solving improved by about 0.83 compared to baseline. The percentage of direct improvement in Subject 6 compared to the baseline is 5%. In Subject 8, the experimental application has affected the performance of information processing. The effect size showed that information processing improved by about 0.26 compared to baseline. The percentage of direct improvement in Subject 7 compared to the baseline is 7%. In Subject 8, the experimental application has affected the performance of information processing. The effect size showed that information processing

improved by about 0.96 compared to baseline. The percentage of direct improvement in Subject 8 compared to the baseline is 21%. In Subject 9, the experimental application has affected the performance of information processing. The effect size shows that information processing improved by about 0.52 compared to baseline. The percentage of direct improvement in Subject 9 compared to the baseline is 7%.

Conclusion

The results showed that computer-assisted cognitive rehabilitation improves problem-solving skills in children with Down syndrome. It was also shown that computer-assisted cognitive rehabilitation in children with Down syndrome improves problem-solving skills. With a glance at the effect size of the sum index of the Tower of London score of these children after the intervention, it can be concluded that the variations are due to the experimental application. These results are consistent with those of a study conducted by Dren on psychiatric patients on whom cognitive rehabilitation interventions improved their problem-solving performance. The results revealed that computer-assisted cognitive rehabilitation therapy improves information processing in children with Down syndrome. It was also shown that computer-assisted cognitive rehabilitation improves information processing in children with Down syndrome. With a glance at the effect size of the reaction time index of these children after the intervention, it can be concluded that the variations are due to the experimental application.

Ethical considerations: Ethical principles are fully observed in this article. Including the principle of confidentiality, confidentiality of personal information, consent and informed participation in the research.

Fund: This contest has no financial sponsor.

Conflict of interest: The authors declare that there is no conflict of interest in the present study.

Thanks: We thank all the families of Dunn syndrome who helped us in this research.

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