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The effect of 8 weeks of aerobic training on cognitive performance in children with learning disorders

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Abstract

Introduction: Learning disorder is one of the most challenging problems in psychology and education. An important feature of children with learning disorder is impairment of memory functions. We aimed to investigate the effect of aerobic Training on cognitive performance improvement in elementary girl students with learning disorder.

Materials and Methods: The population in this study consisted 45 girl students (8 years) of Sarayan city in the 2013-14 academic year that 30 cases were selected by simple random sampling, and they divided randomly in two equal control and experimental groups. At first, learning disorders were checked through interviews with children and parents, background and run test Wechsler. The participating children hadn't illness such as epilepsy. Cognitive performance was evaluated using Wechsler Intelligence Scale for Children-Revised. The experimental group received 8-week aerobic training therapy. Statistical analysis using descriptive and analysis of variance was performed using SPSS, version 18.

Results: After 8 weeks of aerobic training on improvement children´s cognitive performance with learning disorders had a significant influence in the experimental group than control group (P<0.05).

Conclusion: Aerobic training can be used as one of Non-invasive and non-pharmacological method has been positive effect improving of cognitive performance in children with learning disorders.

Keywords: Aerobic exercise, Cognition, Learning disorders, Performance

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Introduction

Since the students as the fundamental pillar of the educational system of the country have a special role and position in achieving the purposes of educational system, paying attention to this group in terms of education and physical-psychological health leads to further flourishing of the society's educational system (1). In terms of learning level, the students are not similar in different ages and different educational courses and especially in the primary educational years, some of them lose the standard conditions for their group and make teachers introduce them to the experts. Although these children perform normally and like their peers in terms of physical development, weight and height, intelligence, speaking, playing and interaction with the others and self-help skills, but when they go to school and want to learn writing and reading, they will face serious problems (2).

The Department of Education of the United States and the general low 101-476 define the learning disorder as follows: the disorder in one or more fundamental psychological processes which raises problems in understanding or using verbal or writing language and may show itself in the form of incomplete ability in listening, thinking, speaking, reading, writing, spelling words or mathematics calculations (3). According to the Diagnostic and Statistical Manual of Mental Disorders (DSM-IV) the learning disorders are diagnosed when the progress in standardized tests for reading, mathematics or written expressing is significantly below the expected level based on age, education and IQ (4).

The prevalence of this disorder from one society to another one is different regarded to the used criteria. In Iran, Jalil Abkenar reported the prevalence of the learning disorder between 7.2% and 30% which averagely involves 10 to 20 percent of students'

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population (5) in 2013. In 10 recent years, the students with learning disorders have been increased to 38 percent (6). These studies have indicated that the number of children with learning disorder has been rapidly increased like some other inabilities and this can be the reason of the significance of more studies in this field (7). No wonder the brain as the most complex structure in the universe that have been identified are described. Since specific learning disorders, neurological nature and learning functions in the brain and nervous system are formed, it can be said that defects in the functioning of the central nervous system as one of the most common causes of learning disability are raised (8). Regular physical activities lead to balance of the hippocampus which has a significant impact on learning and memory (9). As mentioned by the Centers for Disease Control and Prevention, research has shown that physical activity can increase brain capillaries, blood flow, oxygen, production and the growth of nerve cells in the hippocampus (the center of learning and cognitive functions), levels neurotransmitter, development of neural connections, neural network density and volume of brain tissue, affect brain physiology. These changes will help to improve cognitive functions such as attention, information processing, information storage and retrieval, increased positive affect, reduce feelings of lust and pain. It can be said increases cognitive function, and in particular executive function through physical activity (10).

Studies conducted on mice have also reported anatomical changes in the brain after exercise or environmental enrichment. These changes include increased neurogenesis because of increase in the number of neurons, increased survival of neurons, and increase in the number and length of dendrites. Because of the role of dendrites in the formation of synapses and the connections between nerve cells, these structural changes lead to stronger potential for data processing (11).

Overall, a significant category of studies has introduced dopamine and norepinephrine as two neurochemical factors responsible for learning disability. The findings of computerized tomography (CT) indicate lower rates of brain metabolism and blood flow in people with learning disability compared to healthy people (12). Physical activity leads to increase in blood flow to the brain, levels of norepinephrine and dopamine, and leads to reduction in stress, improves mood and thus improves the academic success of students (13). Interestingly, that part of the brain that processes motion is the same part that processes learning. It is surprising that in the brain there is not just one motional center. Movement and learning have mutual and permanent interaction. In fact, that part of the brain that is involved in almost all learning, i.e., the cerebellum, depending on the type of physical exercise is forced to have high activity.

Currently, the researchers have found that a molecule called Irisin, which is produced in the body during endurance exercise, can have nerve protecting properties. By artificially increasing Irisin in the blood of mice, the researchers could activate genes involved in learning and memory. Increase in the Irisin levels in the blood can increase the activity of genes involved in learning and cognitive functions (14).

Movements or rhythmic aerobics is a method of training of interest to children, especially adolescents. These movements and activities have a coordinated nature and proper implementation of them needs various movements with regular execution that require specified sequences. Since these movements are often done with happy music en masse, people are motivated to participate in it (15). Aerobic is an exercise done with a series of regular movements with a special planning and rhythm. Medically, this sport is an effective tool to prevent depression, impatience, and chagrin, because the endorphin hormone is produced in the body and causes vitality, mental focus, and intellectual creativity. Moreover, aerobic enhances nerve-muscle coordination, and strengthens memory (16).

There is a relationship between cognition and music. Researchers believe that short-term memory performance while using rhythmic auditory stimulation intermittently is better than while using visual stimulation. It is said that music strengthens memory by mental imagery (17). Mirbeha quoting from Gardner suggests that music can be described as one of the factors organizing children's cognitive processes (18). Mix of these sports movements to music and poetry and rhythmic and melodious songs adds to the effectiveness of this approach in working with children.

Music has a significant impact on the plasticity of cortical activity and since in children with learning disorders there are various sensory ways, a part of which is due to neurological limitations, the use of music and rhythm in the form of games and sports at the same time increases and proliferates neural branches. In other words, long-term sensory stimulation increases brain synapses and eventually leads to sensory perception at high levels (19).

Therapy through dance or movement therapy as a

process affects further cognitive social and physical integration of the person. Rhythmic movement therapy is a form of psychotherapy based on the creative use of a move to restore the ability of and innate responses, and focuses on the impact of dance on intelligence changes (20). Given the importance of the subject, and the lack of adequate studies in this field, conducting research that by appropriate interventions can take a step in the field of fast development and improvement of cognitive performance of children with learning disorder seems necessary. The aim of this study was to investigate the effect of 8 weeks of aerobic exercise on cognitive performance in children with learning disorders at elementary schools in Sarayan.

Materials and Methods

The clinical trial study with the plan of pretest-posttest and has two experimental and control group; it was performed in filed form. The studied statistical society included 8 years old girl students of primary schools in the school year of 2013-2014 in Sarayan Township who were referred to Tavana education center which has official license from the organization of education of special children by the teachers of usual classes due to some problems in their official education process and the experts of the mentioned center determined them as the children with learning disorder. In the current study, firstly they certainly diagnosed the learning disorder in these children through interview with the child and her parents and investigation of her background and performing Wechsler test; and also they found that the participant children in this research had no other disorder or disease like epilepsy, etc. the whole number of these people is 45 and in the current study 30 persons of them were randomly selected and considered as the sample. Then all participants were randomly divided into two 15-person groups of experimental and control group. After explanation of the purposes and the performance way and the privacy of information for the parents, the participants and their parents were completely satisfied to cooperate in the implementation of the study. When inviting the test group to participate in the process of education of Aerobic exercises before the beginning of the main exercise protocol, the families of the control group's participants committed that these children do not participate in any exercise class except the school's exercise classes in the 8-weeks process of this study. Before the presentation of independent variable, both of groups were evaluated in terms of cognitive function by revised children's Wechsler test. The Intelligence scale of Wechsler for children (WAISC) has been prepared by. Wechsler in 1949 in order to evaluate the children's intelligence. WISC scale was revised 25 years after its codification in 1974 and after normalizing, it was named as the Wechsler Intelligence Scale of Children- Revised (WISC-R). This scale has six verbal subscales (information process, similarities, mathematics, vocabulary, comprehension, and digit span) and six non-verbal or practical subscales including (image completion, image adjustment, cube design, symbol search and mazes). The two subscales of mazes and digit span have the storage aspect. Thus with performing WISC-R, three kinds of IQ are achieved including verbal, practical and overall IQ. The WISC-R test is from the most acceptable and frequently used tests to evaluate children's intelligence. The validity of this test has been reported 0.97 for verbal intelligence, and 0.93 for the practical intelligence through split-half method (21).

The exercise plan included 8 weeks and sub-alternation of 3 sessions each week between the hours of 8 to 9 A.M. under the supervision of Aerobic instructor and each session lasted 45 minutes. The exercise program used in this study followed Gallahue and Ozmun recommendations about physical education programs and four levels of classified growth rhythmic movements (22). It was tried as far as possible, to use movements in which the two main elements of children's actions that means stability and mobility exist. Each session consisted of 10 minutes of warm-up exercises such as slow and stretching movements, 30 minutes of main aerobic workout including exercises with low impact such as in situ step, Step 7, Step 8, the knee, the leg, hamstring, L, biceps, and finally, 5 min of cooling down. At first, the movements were taught simply by understandable names. For example, in Figure 1, image A was taught as move seven, and image B was trained as eight. When children learned movements, movements were taught in combination. Like image C that shows the combination of seven and eight.

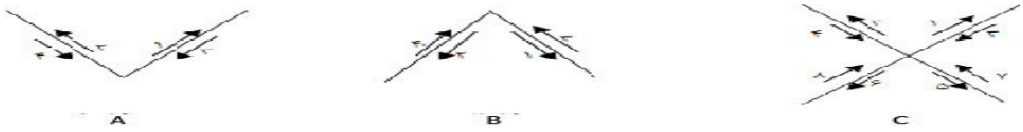

Figure 1. The method of training aerobic movements

Besides learning the shapes of the movements, they had to pay attention to order, rhythm, balance, the order to use right and left leg, and controlling balance without looking at the leg. Practice sessions' music was selected by the instructor with the rhythm that its aim is to use 60 to 65 percent of heart rate reserve in subjects. Subjects' heart beat was controlled with electronic stethoscope during the practice and the amounts of subjects' stored heart beat were calculated by the Karvonen formula. Heart rate was measured at 8 Am, after 15 minutes of rest and in a sitting position (20). At the end of the practice period the evaluation process of the posttest was done for both groups and the results of pretest and posttest were controlled and statistical analysis was performed. In the statistical analysis, in order to compare two groups, first all of quantitative variables were tested for normality by the Kolmogorov-Smirnov test and their normality was proved. Then, in order to compare two groups MANOVA statistical model was used. The significance level of test analysis and all analyses were $P<0.05$, and all analyses were performed by the use of SPSS software version 18.

Results

In this study, 30 female students with learning disorders were studied. Table 1 shows mean and SD of height, weight, and body mass index (BMI) of the students.

Table 1. Mean and SD of height, weight, and body mass index of female students with learning disorders

Age (year)	Frequency	Weight (kg)		Height (meter)		Body mass index (kilograms per meter squared)	
		Mean	SD	Mean	SD	Mean	SD
8	30	23.8	5.6	123.5	8.8	15.5	2.2

Table 2 shows the mean and standard deviation scores in the experimental and control group in verbal intelligence quotient and its sub-tests, practical IQ and its sub-tests tests, and total IQ in pre-test and post-test.

Table 2. Descriptive indicators in the control and experimental groups of total scores in in verbal intelligence quotient and its sub-tests, practical IQ and its sub-tests tests, and total IQ in pre-test and post-test

Group	Test status	Indices	General	Similarity	Calculation	Vocabulary	Comprehension	Completion of pictures	setting pictures	Cubes	Attaching parts	Cryptography	Verbal IQ	Practical IQ	Total IQ
Aerobics	Pretest	Mean	9.73	9.87	8.13	8.27	10.87	10.63	8.27	10.60	10.80	7.40	0.846	0.747	94.6
		SD	3.47	3.06	3.37	4.13	2.82	2.99	2.21	2.32	2.11	3.29	0.410	0.786	13.2
	Post test	Mean	0.8010	10.07	8.73	8.80	11.47	11.07	8.80	10.87	11.00	8.67	0.849	0.350	100
		SD	3.27	2.84	3.53	3.50	2.47	2.21	2.04	2.29	2.20	3.30	0.859	0.106	12.4
Control	Pretest	Mean	9.07	11.20	7.73	8.53	8.87	9.40	9.47	10.33	11.53	8.73	0.445	0.449	94.8
		SD	3.17	1.56	4.06	2.16	1.80	2.13	1.80	2.16	2.03	1.87	0.608	0.275	0.6010
	Post test	Mean	8.60	10.60	7.53	7.93	8.53	9.33	9.20	10.20	11.00	9.40	0.243	0.149	92.3
		SD	3.13	1.68	3.83	2.21	1.68	2.49	1.89	2.07	1.92	2.66	0.657	0.426	10.2

Results in Table 2 show that the average of verbal IQ scores for the group treated with aerobics, in the pre-test and post, are 46.8 and 49.8 respectively, and the average of verbal IQ scores for control group in pretest and posttest are 45.4 and 43.2 respectively.

Average practical IQ scores for the group treated with aerobics in pre-test and post-test are 47.7 and 50.3 respectively, and the mean of total score of practical IQ for the control group in pre-test and posttest are 49.4 and 49.1 respectively. Average total IQ scores for the group treated with aerobics in pre-test and post-test are 94.9 and 100 respectively, and the mean of total score of total IQ for the control group in pre- test and posttest are 96.3 and 92.3 respectively. Scores of other sub-tests are given in Table 2 separately for group and testing phase.

At the same time, the significance of these changes during ANOVA inferential statistics shows that the differences are significant. Therefore, equality of compound average IQ scores in the two groups (being in the intervention aerobics group and in the control group) is not achieved, and this means that interference with aerobics increases IQ scores (P=0.01). Chi Eta share has is equal to 0.72 this means that about 0.72 percent of multivariate changes of the total IQ scores of the participants in the intervention group are due to aerobics. Results of univariate tests evaluate the segment to segment significance of the components separately. Results of univariate tests are listed in Table 3.

Table 3. The results of univariate analysis in IQ and its components

		Sum of squares	Mean Square	F	Significance level	Impact size
Components	General information	17.63	17.63	5.21	• 0.03	0.15
	Similarities	4.80	4.80	2.48	0.12	0.08
	Calculation	4.80	4.80	6.10	• 0.02	0.17
	Vocabulary	10.80	10.80	9.69	• 0.001	0.25
	Comprehension	6.53	6.53	8.73	• 0.001	0.23
	Verbal IQ scores	192.53	192.53	34.09	• 0.001	0.54
	Completion of Pictures	1.63	1.63	1.12	0.29	0.03
	Setting Pictures	4.80	4.80	4.38	• 0.04	0.13
	Cubes	1.20	1.20	3.87	• 0.05	0.12
	Assembly	4.03	4.03	13.88	• 0.001	0.33
	Cryptography	2.70	2.70	0.89	0.35	0.03
	Practical IQ scores	64.53	64.53	9.17	• 0.05	0.24
	IQ scores	480.00	4800.0	26.58	• 0.001	0.48

Significant difference between control and experimental group According to ANOVA analysis results, since the observed p at 95% level of confidence is less than critical *P* (0.05), the difference between pre- and post-test of these components is significant and aerobic therapeutic intervention has improved performance of the subject in the following components: General information component (*P*=0.03), calculation component (*P*=0.002), vocabulary component (*P*=0.001), reading comprehension component (*P*=0.001), verbal IQ component (*P*=0.001), setting pictures component (*P*=0.04), assembly component (*P*=0.001), cubes component (*P*=0.05), practical intelligence components total score (*P*=0.05), and components of the overall IQ score (*P*=0.001). In other differences sub-tests, there no differences and according to descriptive results, there was no significant difference.

Discussion

The aim of this study was to investigate the effect of 8 weeks of aerobic exercise on cognitive performance in 8-year-old children with learning disorders at elementary schools in Sarayan in 2013-14 academic year. Results showed that there is a significant difference in the experimental group pre-test and post-test. In other words, the group that did aerobic training for 8 weeks showed significant improvements in cognitive function and in the control group who were prevented from doing these exercises, the difference was not significant. Two mechanisms have been proposed to explain the effects of exercise on cognitive function: 1. oxygen hypothesis that measures blood flow to certain areas in the brain and 2. Stimulate neurotrophic hypothesis, which shows promotion of neuromuscular activity of the brain centers that leads to higher brain function (23). Physical activity prevents loss of cognitive activity through different molecular mechanisms of learning such as neurogenesis, synaptogenesis and angiogenesis through interaction with hormones, secondary messengers, and neural growth factors. Physical activity, especially aerobic exercise can have a positive effect on many aspects of brain function and cognition (24). Exercise therapy directly affects the structure and function of the brain and also increases aerobic capacity to boost blood flow to the brain, improves the utilization of oxygen and glucose in the brain, accelerates the transfer of biochemical, and increases blood antioxidant enzyme activity (Glutathione peroxidase GSH-PX) for the rapid elimination of free radicals (9). In a study, Gable-Halle, and Halle and Barry Cheung concluded that aerobic exercise (aerobic exercise and dance increase body needs to the use of oxygen) has a positive effect on the behavioral performance of people with learning disabilities and cognitive capabilities and abilities alongside them (25). Ghanaiyi Chamanabad also examined the effects of rhythmic movement exercise on memory numerical function of children with specific learning disorders and concluded that there is a positive relationship between memory of rhythmic movement and numerical memory of students with special learning disabilities, so that students with learning disabilities who have been affected by these variables have acceptable numerical memory. These findings are consistent with the view that recent theories of sensorimotor learning and development of cognitive development determine the fundamental importance of moving. In addition, movement plays an important role in the human cognitive activity and it seems that we think with your body movements (8). One of the important features of children with learning impairment is loss of attention whose main reason is the increase or decrease in the amplitude of the brain waves especially theta waves (8-4 Hz) and Delta (4-1 Hz) in excellent subjective performance. Studies show that the most frequent Electroencephalography

(EEG) abnormality in children with learning disabilities is increased theta compared with normal group and decreased alpha activity in resting. Thus, increase in brain slow waves (less than 10 Hz) in different areas of the brain leads to foggy thinking, slow reaction times, failure to account, poor judgment, lack of impulse control and attention and arousal in people. Thus, reduction in attention in these people can be explained to be because of abnormalities in brain waves (26). Several studies show that aerobic exercise has beneficial effects on cognitive functioning. Aerobic exercise can affect brain waves and increase alpha, beta and theta waves (9).

Some studies have reported that cognitive function of people increases after participation in exercise program. It is thought that movements could help stabilize activities, reminders, request and apply cognitive concepts. The above findings are consistent with results of this study and approve them. Perhaps the effect of exercise on cognitive performance in children with learning disorders can be ascribed to a series of changes in certain regions of the brain that result in increased secretion of neurotransmitters such as acetylcholine, serotonin and noradrenaline. This neurotransmitter causes changes in the brain electrophysiological activity (11). These changes make improvements in cognitive functions such as attention, information processing, information storage and retrieval, increased positive affect, reduced sensitivity to pain cravings and improve (10).

Many discussions have been raised about the impact of physical activity on cognitive function and memory, and underlying mechanisms involved are not definitive, but it is assumed that this effect occurs with some changes in the body. Many animal studies have examined fundamental changes of physical and mental activities and shown increased brain volume, insulin-like growth factor, brain-derived factor, angiogenesis, neurogenesis, and synaptogenesis. Human research is limited because of ethical considerations. Colcombe et al examined synaptogenesis (an increase of synapses and neurotransmitters) and its impact on the human brain and concluded that aerobic exercise affects brain's gray matter volume (27). Erikson et al. with more accuracy showed that changes have occurred in increasing the volume of the hippocampus and spatial memory (28). However, Colcombe et al in their previous research did not believe in the direct impact of aerobic exercise on brain tissue density and expressed that aerobic exercise can only prevent deterioration (27). Other studies in the field of angiogenesis showed that physical activity increases blood flow in the brain capillaries, and blood flow in the brain particularly in the hippocampus. With MRI, Pereira et al. concluded that 12 weeks of aerobic training increases cardiovascular fitness and increases dentate gyrus blood volume, which is a measure of cognitive function (29).

Aerobic exercise has a positive effect on executive control movements such as planning, scheduling, working memory, interference control, and coordinating the work. Rhythmic movements, in addition to being an effective tool for education provides a base for skill and basic motor training. They can affect cognitive processes, attention, perception, concentration, coordination nerve-muscle growth, and personal connections. They can remind the point that physical activity and exercise therapy are effective and parents can use behavioral and movement treatment instead of simply using drugs. Of the limitations of this study, limited number of samples and the problems of working with students with learning disorders such as lack of parental involvement and lack of timely presence of the subjects in the therapy-training sessions can be mentioned. It is suggested that similar research with a different kind of exercise protocols and different age groups on other behavioral disorders be done to express the results more generally. It also suggested that the effect of gender on the effectiveness of this method of treatment be examined. Due to the limited number of participants, it is recommended that research be done on people with quite similar learning disorders so that the effect of exercise on any of the types of learning disorders is separately studied.

Conclusion

According to the findings obtained from this study, it appears eight weeks of aerobic exercise improves the cognitive performance of children with learning disorders. In general, it can be concluded that in this study, the purpose of doing rhythmic exercises was to increase children's perception of spatial-time information such as doing regular physical movement, with a specific rhythm accompanied by music. Spatial concepts such as up, down, forward, backward, right, left, inside, outside and so on were taught en masse through hand and foot gestures.

Children during rhythmic training sessions must understand the rhythm produced and repeat it two times with the group. In fact, rhythmic movements teach the child how to respond to what he hears or sees. Thus, based on this study, it can be expected that with the continuing participation in rhythmic

movement programs, some of the issues of children with disorder in producing new moves schemas be solved via implementation of perceptual-motor skills. This can be of special interest to those involved in issues of children with disorders.

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