JRSR 8 (2021) 40-45

Journal of Rehabilitation Sciences and Research

Journal Home Page: jrsr.sums.ac.ir

Original Article

Effects of Rhythmic Exercise Variability on Auditory Memory and Visual Attention of Adolescents with Diplegia Cerebral Palsy

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ARTICLE INFO

Article History:
Received: 02/09/2019
Revised: 07/03/2021
Accepted: 12/04/2021

Keywords:
Exercise
Memory
Attention
Cerebral palsy
Vision
Auditory perception

Please cite this article as:
Kiani Ejgerdi Z, Meshkati Z, Badami R. Effects of Rhythmic Exercise Variability on Auditory Memory and Visual Attention of Adolescents with Diplegia Cerebral Palsy. JRSR. 2021;8(1):40-45.

ABSTRACT

Background: This study has been conducted aimed to investigate effects of rhythmic exercise variability on auditory memory and visual attention of adolescents with diplegia cerebral palsy.

Methods: This study was a quasi-experimental intervention with an applied purpose, as a single-subject study with multiple baselines design across different subjects during a 1-month follow-up period. Three exceptional 14- to 16-year-old students of Taha Physical Motor Complex in Isfahan were purposefully selected according to the inclusion criteria. The research tools included Wechsler auditory memory and Toulouse-Pieron visual attention tests. The participants were trained in 16 sessions of 30 min of researcher-made rhythmic exercises in such a way that along with changes in rhythm speed, the speed of the exercises also changed. For data analysis, describing the scores of research variables before and after the intervention, increase in scores, Cohen variability, effect size and linear diagram of scores were used.

Results: Evaluations showed that rhythmic exercise had a positive effect on improving auditory memory of all three subjects. Also, visual attention of the first subject had a large increase, visual attention of the second subject had a moderate to high increase, and visual attention of the third subject had a moderate increase.

Conclusion: According to the results of the present study, it can be concluded that variable rhythmic exercise can be used to improve auditory memory and visual attention in adolescents with cerebral palsy.

Introduction

Cerebral palsy is a disorder of movement and posture due to damage or abnormality of the nervous system and one of the most common causes of disability in children. Cerebral palsy is often associated with sensory, perceptual, communicational, behavioral, and musculoskeletal disorders and leads to limited activities [1]. The problems of those with diplegia cerebral palsy related to visual and auditory disorders include poor visual attention and auditory memory [2]. Attention is a cognitive activity to maintain the focus of the mind and body to perform motor tasks that are essential for successful functions [3]. If there is a problem with the information perceived through the visual system, it causes dysfunction [4]. The primary and secondary disorders in the visual cortex of the brain can lead to blindness, lazy eye, visual field disorders, lack of visual recognition and lack of vision pursuit [5]. The physical and speech disorders depend on visual attention. Those who have experienced visual disorders have less improvement in motor skills than others [6]. This encourages us to provide a learning ground for these children. Listening is a complex and active process that, in addition to hearing,

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involves interpreting and responding to other messages. Strengthening the ear through hearing increases children's sensitivity to auditory stimuli. The stronger the ears in recognizing auditory stimuli, the more attention. For this reason, music can design a variety of programs to strengthen hearing and various games to accustom children to auditory attention [7].

Studies have shown that listening to music causes physical changes in the brain to coordinate and synchronize neural patterns [8]. Rhythmic auditory stimulation method is a neurophysiological technique that uses psychological effects of auditory rhythm on the motor system to improve motion control in rehabilitation and therapy [9]. Music is mainly used to integrate tactile, auditory and visual sensors [10]. The researchers have found that music therapy such as listening to music, playing music and even rhythmic movements accompanied by music will improve motor skills, increase eye-hand coordination, strengthen motor control and improve joint range of motion [11]. A study entitled "effectiveness of motor-rhythmic games on improving auditory attention and sequence of children aged 6 to 7 years" showed that the strategy of exercise rhythmic movements improves students' auditory attention and sequence [12].

This method provides rhythmic auditory patterns to improve gait style and movement patterns in patients with movement disorders. Ghai et al. in a study investigated the effect of rhythmic auditory commands on gait in those with cerebral palsy. This study demonstrated the benefits of rhythmic auditory commands to increase gait performance and stability in those with cerebral palsy [13]. Ghai also found that rhythmic auditory stimuli are useful for improving arm function in those with stroke [14]. In general, no study was found on strengthening auditory memory and visual attention by rhythm changes in music in exercise of children with cerebral palsy. Regarding the importance of these two categories, the need for such research becomes apparent. Therefore, the present study seeks to answer the question, whether music exercise with variable rhythm can improve auditory memory and visual attention in children with cerebral palsy?

Methods

Procedure

The present study was quasi-experimental, applied in terms of purpose and cross-sectional in terms of time. This study was conducted as a single-subject study with multiple baselines design across different subjects, pre-test and post-test during a one-month follow-up period. Single-subject designs or single-study designs are used in two ways: first, when the effect of the studied method on a person may be offset by the effect of one method on another; and second, when it is not possible to find a large number of people with similar problems so that they can be divided into random experimental and control groups [15]. In these designs, only a subject is studied at a time, and changes resulting from implementation of treatment or exercise methods are evaluated in relation to the same subject, not in relation to others. In other words, for implementation of these designs, the subject plays the role of both the experimental subject and the control subject [16]. In multiple baseline designs, instead of collecting information from one subject, a certain behavior of several subjects is measured to determine the baseline. The experimental manipulation is then performed on a regular basis and over a period of time for each subject so that all subjects are affected by the independent variable [17].

Subjects

The participants in this study were 3 adolescent students (2 boys and 1 girl) with diplegia cerebral palsy and age range of 14 to 16 years from Taha Physical Motor Complex in Isfahan. These students were selected by convenience and purposeful sampling method considering inclusion criteria including the ability to function in the upper extremities, no permanent deformity in the upper extremities, no vision, hearing, and mental problems and no epilepsy. Inclusion criteria were determined by direct observation and reference to the student's health record at school, which was set by the health instructor based on the physician's periodic checkup. All parents of students signed the consent form. Students also expressed their satisfaction with participating in the study. The present article is taken from a master's thesis of motor behavior Isfahan (Khorasgan) branch, Islamic Azad University with code number 23821402961056.

Data Collection

Wechsler auditory memory and Toulouse-*Pieron* visual attention tests were used in this study for data collection.

Wechsler Auditory Memory Scale is WMS-IV / Wechsler. The test is performed in such a way that the examiner reads a series of numbers to the subject and the subject should repeat the exact same numbers. The first attempt starts with three numbers and one is added to the number of numbers in each attempt. Finally, it will be 16 attempts. The digit span is applied separately in two ways forward (16 points) and reverse (16 points) and the total is 32 points. Each question consists of two attempts, both of which should be performed even if the subject fails in one attempt. Each attempt is read to the subject at a rate of one digit per second. No attempt is repeated. If the subject answered correctly, a score of one and if he answered incorrectly, a score of zero is given to him. Stopping the test for each of the presentations, either forward or reverse, after two consecutive zero scores in two attempts is related to each question. Finally, the sum of the scores for the subject is calculated [18]. The validity of this tool has been confirmed in Iran. The reliability coefficient of digit span test by the method of split-half and retest is 0.71 [19].

Toulouse-*Pieron* accuracy *comet square* test was used to measure visual attention. In this test, 80 comet squares are drawn on a piece of paper in no particular order. The subject should identify and cross out the three squares marked at the top of the page at the specified time [3 min]. 1 point is given to each of the squares that are crossed out correctly at the specified time, and 0.5 point is deducted

from each of the squares that are crossed out incorrectly and the number obtained showed the result of the subject during the experiment. Validity of retest of this test in Iran has been reported 0.86 and its validity is 0.79 correlated with Gray-Wilson *Personality Questionnaire [3]*.

The data were collected by field method. After obtaining permission from the Welfare Organization of Isfahan Province and in coordination with the director of Taha Physical Motor Complex in Isfahan, the researchers invited the parents of the students who after the full explanation about the study, consciously signed the consent form. The subjects also verbally expressed their satisfaction and interest in participating in the study. In order to design exercise protocol; first, the researcher studied books and articles, considered the experiences of occupational therapists and viewed sites offering exercises and games related to exceptional children, and exercises were selected initially. Also, a music expert was hired to adjust the rhythm used in this study. Rhythm with different tempos was suggested. Then, the selected games and exercises, along with the suggested rhythms and tempos, were performed on two students [other than the main subjects] as a pilot study at several stages. Finally, according to the children's ability and proportion of the exercises to the study objectives, appropriate exercise protocol and rhythm were determined. A rhythm of 4.4 was chosen [with 4 replications] [20]. The speed of the rhythm was designed to be challenging and slightly higher than the students' ability to challenge them. The tempo of 50, 60 and 70 beats per second [randomly] was selected and adjusted by the metronome and recorded on a CD. The desired rhythm was played to the participants at the stages at the same time as the exercises. The exercise was performed in the complex gym under the same conditions for all participants; light, sound, tools, and etc. The environment, equipment, exercise protocol and other related items were adjusted according to the conditions and restrictions of the subjects. The subjects were provided with the same white shirt. After every four sessions and at the end of the study, the subjects were encouraged to receive prizes. In this study, a multi-baseline design was used for different subjects. They have the ability to prove cause-and-effect relationships in vitro. This design, with the step-by-step entry of participants, enables the researcher to eliminate the effect of confounding variables and explain changes in the dependent variable based only on the independent variable [15]. Therefore, in the present study, baseline data on auditory memory and visual attention were collected for all three subjects in three sessions. Then the exercise protocol for the first subject was started individually and the other two subjects remained in the baseline. After one session of the intervention of the first subject, the intervention began for the second subject and the third subject remained in the baseline. Also, at the same time with the third intervention session of the first subject, which coincided with the second intervention session of the second subject, the third subject entered the intervention. The intervention process continued until the intervention was performed for three subjects for 16 sessions of exercise protocol. It should be noted that during the intervention process, after all four sessions, auditory memory and visual attention tests were taken from all three subjects. Also, two post tests were taken from the subjects one week apart, one month after the end of the last exercise session, which was held without exercise. The intervention was performed in 16 sessions and 3 sessions per week for 30 min. The exercise was performed in such a way that first the participants went to the gym separately at the appointed time (11 to 12 in the morning) and after changing their clothes and preparing for 10 min, they did the stretching exercises with the game in order to warm up. Then, the main body of the exercise was performed for 15 min, and at the end, the cooling exercise was done for 5 min.

Training Protocols

Training Protocols was researcher-made. In the first sessions, low-intensity, low-time, low-number exercises were done. During the sessions, in order to increase the exercise load and better effectiveness, the time, intensity and number of exercises were increased, and the exercises were done in combination [12]>. It should be noted that in the initial sessions, the researcher assisted the subjects to do the exercise. On the one hand, the exercise was done simultaneously with the rhythm for the subjects, so that if the rhythm speed was low, the exercise was done by the subjects at a low speed, and when the rhythm speed was higher, the speed of the exercise would also increase. The subjects tried to match their performance with the speed of the rhythm. The exercise protocol included the following:

1. Clap: In this exercise, first the subject heats the rhythm several times and then tries to shake the palms of both hands at the same time as the rhythm was heard. Then, in order to make the subject's exercise more difficult, they first put their hands together and then alternate their right and left hands on their thighs. At the next stage, the previous exercise is done in combination with right and left hand strikes alternately on the chest.
2. Send and catch the ball: Two subjects, at a distance, sit in front of each other and pass the ball. This exercise becomes more difficult by increasing the distance between them and using volleyball, tennis and table tennis balls.
3. Throw the ball to the target: The subject throws the ball with both hands towards the small target, the target on the wall and the basket on the ground.
4. Stack paper objects on top of each other: The subject first stacks the glasses in a pyramid with both hands and returns them to the first state. Then, he puts a combination of glasses and plates on top of each other according to the pattern and returns them to their first state.
5. Draw: The subject first begins to draw a straight line on the paper with a pencil. Then, using gouache color [desired color] and ear cleaner, tap on the drawn points on the paper. Then, he draws the desired design with gouache color [desired color] and brush.
6. Throw sandbags: The subject throws small sandbags towards the desired color of the colored ladder on the ground, the desired part of the colored dart on the ground and colored circles stuck together and hung from the ceiling.

7. Throw the table tennis ball towards the target: The subject pushes or throws the table tennis balls towards the glasses that are arranged horizontally at the other end of the table. The glasses are then stacked in a pyramid and the subject tries to hit the ball.

8. Arrange wooden cubes: The subject puts medium-sized wooden cubes on top of each other with both hands so that their balance is maintained. Then, the size of the cubes becomes smaller.

9. Throw colored rings on the cones: The subject throws the colored rings towards the obstacles of the cone that are arranged horizontally at regular distances. The cones are then stacked at irregular distances.

10. Ring game: Two subjects sit opposite each other and when they hear the sound of rhythm, by opening the ropes that are tied to the rings, they release the ring [with both hands] and send it to the subject in front of him.

11. Throw cotton balls towards the target: The subject turns the inside of the ring into an octagon or spider web using paper tape, and throws cotton balls from inside the empty spaces to the other side. At the next stage, the subject's distance from the ring increases.

Statistical Analysis

The data of this study were used by descriptive statistics of scores of research variables before and after the educational intervention, mean intervention, percentage of increase in scores, Cohen variability and effect size, as well as linear diagram of scores.

Results

Table 1 shows the scores of research variables at baseline, interventions and follow-up stages of three participants in this study.

Answering the research questions, while descriptively investigating the scores of research variables before and after the educational intervention, the mean of the intervention, Cohen's variability and the size of the effect, a linear diagram of scores was used. As shown in Table 2, in the variable of visual attention, the mean score in the first subject increased in the experimental intervention compared to the pre-test [62.41% increase] and increased again in the follow-up. The effect size is 0.83 and above. In the second subject, this variable increased in the experimental intervention compared to the pre-test [45.9% increase] and increased again in the follow-up. The effect size is 0.62 and above average. In the third subject, this variable increased in the experimental intervention compared to the pre-test [14.32% increase] and increased again in the follow-up. The effect size is 0.5 and average. In the variable of auditory memory, the mean score of the first subject in the experimental intervention increased compared to the pre-test [35.93% increase] and increased in follow-up again. The effect size is 0.71 and above. In the second subject, this variable increased in the experimental intervention compared to the pre-test [37.97% increase] and reduced slightly in the follow-up. The effect size is 0.75 and above. In the third subject, this variable increased in the experimental intervention compared to the pre-test [49.96% increase] and did not change in the follow-up to the intervention. The effect size is 0.8 and above.

In the following, we show linear diagram of change in scores of research variables of three subjects at the baseline, experimental intervention and follow-up stages (Figure 1).

Discussion

This study has been conducted aimed to investigate effects of rhythmic exercise variability on auditory memory and visual attention in adolescents with cerebral palsy. The results showed that physical exercise with variable rhythm music increases auditory memory of adolescents with cerebral palsy. This finding is consistent with the study results of Ghorbanpour et al. on the positive effect of exercise rhythmic movements and games on increasing auditory memory in students with learning disabilities [21], Zeini et al. on effectiveness of motor-rhythmic games on improving auditory attention and sequence of children aged 6 to 7 years [12] and a review study by Lopez et al. on the use of the role of

Table 1: Changes in the scores of research variables of three subjects at baseline, intervention and follow-up stages

Variable	Subject	Baseline			Intervention				Follow-up	
		1	2	3	2	4	6	8	1	2
Visual attention	1	33	44	50	67	58	70	80	77	77
	2	38	55	72	75	63	86	97	89	80
	3	44	50	51	47	50	64	60	57	56
Auditory memory	1	14	14	20	22	21	23	21	21	24
	2	15	16	19	20	21	25	26	27	24
	3	12	15	20	19	24	27	24	24	23

Table 2: Indices of changes in trend, slope, variability and effect size of test scores on research variables

Variable	Subject	Mean baseline	SD	Mean intervention	SD	Mean continuity of improvement in follow-up	Percent of variation	Cohen variability	Effect size
Visual attention	1	42.33	8.62	68.75	9.07	77	62.41	2.98	0.83
	2	55	17	80.25	14.59	84.5	45.9	1.6	0.62
	3	48.33	3.78	55.25	8.06	56.5	14.32	1.1	0.5
Auditory memory	1	16	3.46	21.75	0.96	22.5	35.93	2.11	0.71
	2	16.67	2.08	23	2.94	22.5	37.97	2.3	0.75
	3	15.67	4.04	23.5	3.32	23.5	49.96	2.63	0.8

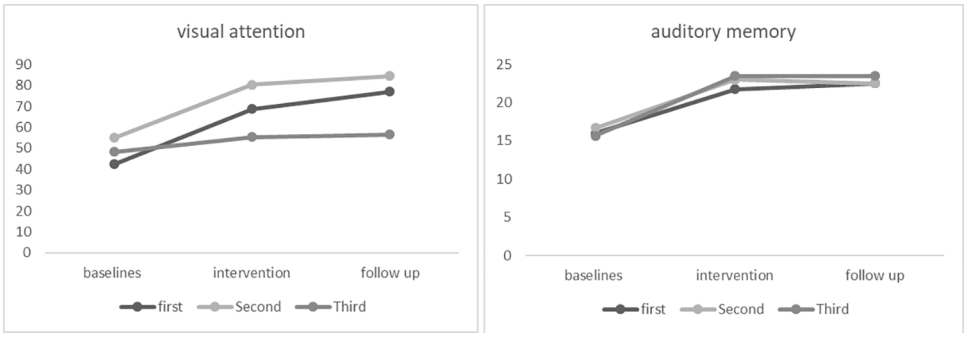

Figure 1: Linear diagram of change in scores of research variables of three subjects at the baseline, experimental intervention and follow-up stages

music movement [rhythmic auditory stimulation (RAS) in neurological rehabilitation of children with cerebral palsy in one direction [22].

Children's attention to auditory stimuli increases by strengthening the ear through hearing. The stronger the ears in recognizing auditory stimuli, the higher attention. For this reason, music can have a variety of programs to strengthen hearing and various games to accustom children to listening attention [7]. Information processing refers to a series of operations in which auditory and visual systems should connect and integrate the stimuli involved in learning to receive, detect, and respond. The operation organize and plan the response to environmental demands. The key concept of RAS is auditory-motor synchronization in the reticulospinal tract [23]. Amygdala is responsible for behavioral responses to stimuli or objects that are biologically important. Amygdala receives information from parts of the temporal cortex. The information include auditory and visual information, and hippocampus is a component of this system that plays an important role in memory [3]. The auditory system increases stimulation of motor neurons in the spinal cord, which is directly affected by downward paths of the brainstem and formation of networks, resulting in passage of cortical sites. In addition, motor sites of the brain, including complementary motor site, basal ganglia, and cerebellum, are activated by the auditory rhythm. Activation of motor sites of the brain through rhythm leads to improved muscle activation and better control of movement, which is due to maintenance of auditory attention and memory [20]. Also, rhythmic movements increase people's self-confidence and social participation, which also accelerates the process of physical rehabilitation [22]. It may be said that music is effective on recalling past events, providing a non-verbal opportunity for a range of unconscious emotions and cognition; strengthening abilities, the concept of self and transforming the mood [12].

The study results also showed that physical exercise with variable rhythm music increases visual attention of adolescents with cerebral palsy. The results are consistent with studies by Abuin-Porras et al. on effectiveness of physical rehabilitation on improving visual attention of children with cerebral palsy [6], Sadri et al. on effectiveness of hearing rhythmic and melodic music on preschool children's visual and auditory attention [7], Zabihi et al. on hearing rhythmic and melodic music on increasing auditory and visual attention and social skills of preschool children [3], and Ben-Pazi et al. who showed that auditory stimulation by music can improve motor function of children with cerebral palsy [24]. The combination of music and motion indirectly activates the communication pathways, involvement of emotions and limbic system of the brain. The limbic system of the brain includes the thalamus, hypothalamus and amygdala and other components and plays an important role in memory, learning and various emotions [3]. The visual stimuli can activate sensory-motor sites. Music stimulates the frontal-temporal-parietal sites of the brain due to its visual, auditory, and motor data. The mirror neurons in these sites of the brain are responsible for hearing and performing or seeing and performing. Using musical motor activities is a way to strengthen motor skills by increasing rhythm perception. Understanding the structure of rhythm and coordinated performance of movements is in fact the main component of a coordinated movement [25]. Music acts as a link between the mind and the body, thus it causes inherent harmony and is used as a stimulus in physical and mental actions and a source of pleasure and beauty [26]. Music increases sensory feedback for those with mobility problems and helps maintain concentration, shift attention from harmful emotions to more pleasurable desires, and manage them [27]. Listening to a rhythmic pattern during activity increases the level of concentration and attention. The auditory and motor cortex are highly involved in rhythm. Rhythm has the ability to encourage the subject to follow and the person's movements are affected by it, thus increasing coordination of movements, and visual and auditory attention [28]. Therefore, in the present study, subjects with cerebral palsy did motor exercise with variable speed, which were often done by hand, when they heard the variable rhythm; since exercise slowed down and accelerated at the same time as the rhythm, auditory and visual receptors were constantly stimulated, and to adapt to these changes, their cognitive domain was activated and finally improved during brain processes improved auditory memory and visual attention.

Due to time limits, it was not possible to perform the test with a quarterly follow-up to observe effectiveness of exercises in the long run. Also, due to the limited sample and lack of access to subjects, it was not possible to conduct this study with a larger group and averaging. Selecting samples from a single city can also be a threat to the external validity of the study results. According to the results of the present study, it is suggested to investigate, if possible, larger groups of experiments and evidence and averaging in future research. Also, the test should

be performed with a quarterly follow-up to observe effectiveness of exercise in the long run. Since rhythmic-musical exercise is a strong motivational stimulus, it is suggested to measure effects of psychological variables such as aggression, mental health and social adaptation on these adolescents in future research.

Conclusion

Regarding cognitive characteristics of children with cerebral palsy is very important. According to the results of the present study and other related studies, physical exercise with music with variable rhythm can be used to reduce the problems of children with diplegia cerebral palsy. It is recommended to reduce the problems of these people by designing and performing rhythmic exercise in groups and continuously during physical education classes for students with cerebral palsy. This finding can be considered in education, welfare centers, therapists, clinics and other educational centers.

Acknowledgment

The authors appreciate all the officials, families and students participating in this study at Taha Physical Motor Complex in Isfahan.

Funds

All research costs were borne by the authors and there was no financial support from other centers.

Conflict of Interests: None declared.

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