



Original Article

The Effect of Aerobic Exercise with Nonlinear Pedagogy on Anxiety, Depression, Motor Proficiency and Cognitive Ability of Boys with Attention Deficit Hyperactivity Disorder

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ARTICLE INFO

Article History:

Received: 03/05/2021

Revised: 28/06/2021

Accepted: 31/08/2021

Keywords:

Nonlinear dynamic

Anxiety

Depression

Motor skills

Attention deficit disorder with hyperactivity

Please cite this article as:

Mohammadi Orangi B, Yaali R, Ghorbanzadeh B, Loprinzi P, Ebdalifar A. The Effect of Aerobic Exercise with Nonlinear Pedagogy on Anxiety, Depression, Motor Proficiency and Cognitive Ability of Boys with Attention Deficit Hyperactivity Disorder. JRSR. 2021;8(3):144-150.

ABSTRACT

Background: This study investigated the effects of the aerobic exercise with music on anxiety, depression, motor proficiency, and cognitive ability of boys with Attention Deficit Hyperactivity Disorder (ADHD).

Methods: This is a quasi-experimental study. Participant's comprised a convenience sample of 36 boys with ADHD. The experimental group (N=18) practiced in non-linear pedagogy ($M_{\text{years}}=11.32$, $SD=1.00$), whereas the control group (N=18) performed ($M_{\text{years}}=11.26$, $SD=0.92$) usual school activities in the traditional method.

Results: After participating in the 8-week aerobic training program, motor proficiency, anxiety, depression, working memory, perceptual reasoning, and processing speed were improved in the experimental group compared to the control group ($P<0.001$).

Conclusion: Based on these findings, among the ADHD children, incorporating music into sports can affect children's anxiety, depression, motor proficiency, and cognitive ability. Increasing participation by incorporating music into sports such as aerobics, can affect children's anxiety, depression, motor proficiency, and cognitive ability.

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Introduction

Attention Deficit Hyperactivity Disorder (ADHD) is a neurodevelopmental disorder where individuals indicate inappropriate developmental levels of inattention, over activity, distraction, and impulsivity which occurs in childhood years [1]. One Iranian study reveals that the number of primary school-aged children with ADHD is rising and about 9.7% of children in Tabriz have ADHD, and this requires special attention [2].

People with ADHD indicate the physical and

behavioral characteristics which affect their general health and wellbeing [3]. Motor proficiency in children with ADHD is lower than normally developing children, which may be an important prerequisite for sport and has a positive correlation with participating in physical activity [4]. The depression in these children is 5.5 times higher than normally developing children [5], and their anxiety is more common than their counterparts [6]. These individuals' cognitive ability (working memory, perceptual reasoning, and processing speed) is less than their counterparts [7]. These problems will put children with ADHD at greater risk in the future, so trying to improve them is of the utmost importance [1, 5].

The treatment and improvement of intervention practices for the children with ADHD were performed

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via various ways. Exercise, a form of motor intervention, is found to be an effective approach for ADHD [8]. In this regard, Mihandoost, showed that students who engaged in an exercise program had a higher potential of being included in society and showed improvement in their academic and social skills [8]. So, Lee, Park, and Seo, examined the impact of horseback riding on anxiety and depression in overactive children and reported similar results [9]. Other studies found that the effects of motor interventions on executive function (working memory) and motor function are positive [10]. Therefore, effective exercise and motor functioning can foster the involvement and participation of children with ADHD in physical activities.

Aerobic exercise was shown to be very helpful for children with ADHD [11]. Furthermore, studies found aerobic exercise to be useful for hyperactive children [12], but combining aerobic exercise with music brings joy and excitement, and, by releasing endorphins, it may help reduce depression and anxiety symptoms [13]. However, the therapeutic effects of aerobic exercise with music (usually music without words) have not been reported on motor proficiency, anxiety, depression, and cognitive ability in children with ADHD. Recent studies utilizing ecological dynamics have reported that when the manipulation of environmental constraints accompanies the education and training of children, it will be better for learning and development. According to ecological dynamics, a nonlinear pedagogy provides a design of a learning environment that increases learners' motivation and effectively improves self-esteem and other features of the individual [14]. A nonlinear pedagogy seems appropriate to enhance physical education and activity participation of all children, including those with ADHD. Because the nonlinear pedagogy is an exploratory approach to teaching and learning or promoting physical education, it is potentially effective in helping all children acquire relevant twenty-first-century competencies, including developing self-esteem, self-awareness, critical and inventive thinking [15] or maybe anxiety, depression and cognitive ability. However, no studies were used non-linear pedagogy to improve these aforementioned concerns that are prevalent among children with ADHD.

In nonlinear pedagogy, an instructor manipulates the environment and task, which helps learners learn skills based on their specific physical characteristics [15]. According to Moy, Renshaw, Davids, and Brymer, unlike the traditional linear method, which adopts a teacher-center approach, the nonlinear pedagogy provides a sound theoretical model of the learning process, which informs learning design and delivery within physical education [16]. In this pedagogy, teachers need to manipulate tasks and environmental constraints to make them more adaptable to the learners' needs to stimulate exploration and to enable them to have an enjoyable environment to solve learning problems [14], but, in the linear method, the trainer uses verbal instructions and feedback, and encourages children to achieve an optimal pattern [16]. Experimental studies in people without disorders showed that the nonlinear method in different cognitive and physical dimensions is better than the linear method [17–

23]. However, today, the number of children and people with certain disorders, such as hyperactivity, is increasing, and by providing the positive effect of movement interventions (such as aerobics with music in a non-linear way), their abilities can be used to improve their personal lives and society. Therefore, this study aimed to analyze the changes in motor proficiency, anxiety, depression, and cognitive ability (working memory, perceptual reasoning, and processing speed) in boys with ADHD who trained in an aerobic exercise program with music for 8 weeks in a nonlinear pedagogy environment.

Methods

Participants

A pretest and posttest design with a control group was employed. The population included boys with ADHD, aged 10-13 [deleted for referees]. 36 students were part of an experimental group ($N=18$, $M_{\text{years}}=11.32$, $SD=1.00$) or control group ($N=18$, $M_{\text{years}}=11.26$, $SD=0.92$) who were diagnosed as having ADHD from a rating scale using by Dupaul, Power, Anastopoulos, and Reid, participants were selected from the elementary school of Tehran and participated in this experiment, then randomized into either a control or experimental group. Criteria for selecting participants were: (1) parental consent, (2) not having physical and psychological problems based on the child's health questionnaire in school (except hyperactivity), and (3) their cooperation. The study was approved by the Institutional Review Board, and the code of ethics IR.UT. PSYEDU.REC.1398. 026 was received. Participants were informed of the benefits and risks of investigation before signing an institutionally approved informed consent document to participate in the study. Parental consent form was received from all the participants' parents. **Anthropometric Measurements:** Participant's height and weight were measured to the nearest 0.1 cm and 0.1 kg, respectively, using a stadiometer digital electronic scale, with body mass index (kg/m^2) calculated from these measures. **The ADHD rating scale was developed** by DuPaul et al. [24]. Each question is graded from 0 to 3, and ADHD was diagnosed when the parental report of the child's was at least 19 points, and the teachers' report of the child was at least 17. The validity of this test in Iran was reported above 70%, and in recent studies, it was used in Iran

Motor proficiency (MS) was assessed using the short form of Bruininks-Oseretsky Test of Motor Proficiency-2nd Edition. This test is a standard tool to examine fine and gross motor skills in children and suitable for ages 4-21. Moreover, this test includes four composite motor domains: fine motor control (fine motor precision and fine motor integration), manual coordination (manual dexterity and upper-limb coordination), body coordination (bilateral coordination and balance), and strength and agility (speed/ agility and strength). Raw scores well above average scores ≥ 70 and standardized scores above average: 60–69 are provided [25]. The validity of this test in Iran was reported above 75%, and in recent studies, it was used in Iran [26]. Interrater reliability in the present study was conducted with two

trained evaluators with the adequate agreement (79.0%).

The Child Anxiety Scale is a children's version of Manifest Anxiety Scale for Adults developed by Taylor and used as Revised Children's Manifest Anxiety Scale (RCMAS) by Reynolds & Richmond [27]. This scale, which is used to evaluate anxiety disorder, is composed of 37 questions in the self-report form, and each question is answered as yes or no by children and adolescents. The total score is calculated, and higher scores indicate more severe anxiety symptoms; additionally, the symptoms related to various types of anxiety are evaluated. This test is useful for children above 7 years old. The validity of this test in Iran was reported above 75%, and in recent studies, it was used in Iran [28, 29].

The Center for Epidemiological Studies Depression Scale (CES-D) [30] developed by the United States Mental Health Research Institute for epidemiological studies of depression, was used to evaluate depression. This scale consists of 20 questions and is a self-report scale rated by 0 to 3 points. Scores range from 0 to 60, with a cut-off score of 25 for diagnosing major depression. This test is useful for children above 8 years old. The validity of this test in Iran was reported above 75%, and in recent studies, it was used in Iran [28].

The Wechsler Intelligence Scale for Children-Fourth Edition (WISC-IV) was used to assess cognitive ability (CA). This test is a standard tool to assess cognitive ability which provides four composites scores: verbal comprehension, perceptual reasoning, working memory, and processing speed. Three of these composites were retained, perceptual reasoning, working memory, and processing speed. This test is useful for children above 8 years old. This test has validity and test-retest reliability ($r=0.80-0.90$) [31]. The validity of this test in Iran was reported above 75% and in recent studies it was used in Iran.

Aerobic and Music intervention

The experimental group performed aerobic training with music. To do this, in the first step, all of the music from the site (<http://www.pumpyouup.com/free-exercise-music.aspx>), which in combination with aerobic exercise, is suitable for hyperactive children, were downloaded. Subsequently, 24 tracks were chosen, and every session, one of them was played at the gym. Music selection standards included: (1) absence of the reader, (2) follow a rhythmic theme, and (3) different rhythms of music (up, down, normal) to match movements. Music was played from an 8-inch Active V8 speaker with 60 dB power. The coach's role to design the exercise was to lead the participants toward group coordination. The coach played the song and asked the participants to do whatever they liked, but he limited the participants with instructions. The principle of nonlinear method is that the participant explores himself [14], and to achieve this discovery, the coach should not provide feedback; the instructor should not show a pattern to the learners [14], but, he can manipulate the environment in such a way that the learner himself achieves the goal of practice [14]. This limitation is not always restricted by manipulation. Furthermore, in some cases, the instructor can limit

learners with instruction. Aerobic exercise is one of the exercises that the instructor can use instructions to limit the exercise. For example, learners were told that they needed to achieve group coordination when moving their legs. Then, try to coordinate hands. This is different from feedback, since no information are provided on how and when details are moved. The instructor assisted them with moving students, switching tracks, or using tools such as foam to accelerate the coordination. Although participants in this study were only able to achieve very beginner coordination in eight weeks, it did not matter how much coordination they achieved. Because this study aimed to place the participants in a fun environment, without feedback, and without patterns. The instructor did not provide verbal or augmented feedback on performance in relation to the internal body movements of an 'ideal' technical hurdling action (the 'how to do it'), but instead, he provided 'broad statements' that acted as boundary constraints on the selected activities of the learners [14]. Participants completed this intervention for eight weeks, three sessions per week and 60 minutes for each session. The control group performed their routine school activities. Their training sessions were twice a week for one and a half hours each week, and it included aerobic activities with and without music and other physical activities. Furthermore, the training method was linear in the control group. That is, the instructor showed the skill to children and then ask them to practice the optimal pattern, and later, with verbal feedback, he tried to improve their skills.

Procedure

The pre-test was taken by the authors and two of their assistants. At first, the method of implementing Bruininks-Oseretsky test was presented by the researcher to all participants once. Then, the students took the test. Furthermore, each person had the opportunity to take a symbolic test once. During the test, the researcher measured the score according to the Bruininks-Oseretsky test, and one of the assistants filmed the subjects from the sides and front view via a Samsung Galaxy On5 2016. The researcher once again used these videos to ensure that the grade was assigned correctly. The goal was a general score, not the score for each sub-test, and therefore each person scored a total score, that is, the total score of the sub-tests. Anyone completing the Bruininks-Oseretsky test should also have depression, anxiety, and connective ability tests. The scores of this questionnaire were also added up by the researcher and written for each person. Based on pre-test scores, the researcher did a purposive sampling in a way that participants with high, low, and average scores in the Bruininks-Oseretsky test and Anxiety Scale and Depression Scale and WISC-IV were distributed equally in two groups. Therefore, there was no significant difference among groups in anxiety, depression, and motor proficiency scores. After the pre-test, an aerobics instructor trained the experimental groups for eight weeks at a gym.

Statistical Analysis

Information and research data were analyzed using

descriptive statistical methods. The Shapiro–Wilk test was used to determine the normality of the data, an independent t-test was used to examine anthropometric differences among groups in the pre-test and, ANCOVA test was used to investigate the effects of aerobic training on the dependent variable, while controlling for baseline (pre) levels of the outcome variable. The selected level to show the significant statistical difference was $P < 0.05$. Version 22 of SPSS software was used for calculations.

Results

An independent sample T-test was conducted to compare age, height, weight and Body Mass Index (BMI) in two groups. As shown in Table 1, there was not a significant difference among groups for age ($t_{(34)} = 0.75$, $P = 0.45$), height ($t_{(34)} = -0.41$, $P = 0.68$), weight ($t_{(34)} = 0.57$, $P = 0.56$) and BMI ($t_{(34)} = 0.85$, $P = 0.40$).

Table 2 presents the descriptive information and the rate of change of variables' scores. Motor proficiency scores increased 5.84 units in the experimental group. Anxiety scores decreased 4 units in the experimental group. Depression scores decreased 5.06 units in the

experimental group. Working memory scores increased 6.50 units in the experimental group. Perceptual reasoning scores increased 6.23 units in the experimental group. Processing speed scores increased 8.34 units in the experimental group. These changes were less than 1 for all variables in the control group.

One way ANCOVA was conducted to determine the statistically significance difference between the control and experiment group (Table 3). There is a significant effect of training type on motor proficiency ($F = 80.190$, $P = 0.000$, $\eta^2 = 0.708$), anxiety ($F = 109.513$, $P = 0.000$, $\eta^2 = 0.768$), depression ($F = 155.377$, $P = 0.000$, $\eta^2 = 0.825$), working memory ($F = 50.400$, $P = 0.000$, $\eta^2 = 0.604$), perceptual reasoning ($F = 55.004$, $P = 0.000$, $\eta^2 = 0.625$) and processing speed ($F = 60.520$, $P = 0.000$, $\eta^2 = 0.647$) after controlling for pre-test.

Discussion

Our study investigated the effects of aerobic exercise with music intervention on motor proficiency, anxiety, depression, working memory, perceptual reasoning, and processing speed in boys with ADHD. In general, this

Table 1: Comparison of anthropometric characteristics of participants

	t	df	Sig. (2-tailed)	Std. Error Difference
Age	0.751	34	0.458	0.30555
Height	-0.411	34	0.684	1.35186
Weight	0.577	34	0.568	1.49599
BMI	0.853	34	0.400	0.65374

Table 2: Descriptive information on motor proficiency, anxiety, depression, working memory, perceptual reasoning, and processing speed in pre-test and post-test

Variable	Group	N	Pre-test	Post-test
Motor proficiency	Experiment	18	55.88±4.18	61.72±4.52
	Control	18	56.27±4.87	56.88±4.63
Anxiety	Experiment	18	20.72±2.80	16.72±1.96
	Control	18	21.16±2.14	20.94±1.83
Depression	Experiment	18	20.11±2.13	15.05±2.12
	Control	18	20.22±2.12	20.00±2.05
Working memory	Experiment	18	87.44±15.14	93.94±14.48
	Control	18	86.50±13.09	86.94±13.14
Perceptual reasoning	Experiment	18	90.27±14.50	96.50±14.23
	Control	18	91.55±11.37	91.94±11.73
Processing speed	Experiment	18	83.38±15.64	91.72±15.74
	Control	18	82.88±14.94	83.50±14.64

Table 3: ANCOVA results statistics

Group	Achievements					
	SS	DF	MS	F	sig	η^2
Motor proficiency	242.614	GrouP=1 Error=33	242.614	80.190	0.000	0.708
Anxiety	139.128	GrouP=1 Error=33	139.128	109.513	0.000	0.768
Depression	211.849	GrouP=1 Error=33	211.849	155.377	0.000	0.825
working memory	333.681	GrouP=1 Error=33	333.681	50.400	0.000	0.604
perceptual reasoning	303.437	GrouP=1 Error=33	303.437	55.004	0.000	0.625
processing speed	538.248	GrouP=1 Error=33	538.248	60.520	0.000	0.647

study's results showed that aerobic exercise with music in a non-linear manner has a positive effect on anxiety, depression, cognitive ability, and motor proficiency. Although the effect of aerobic exercise on various variables was investigated in previous studies [12, 32], this study combines aerobics and music in a non-linear way to open a new perspective for researchers, which will be discussed in the following narrative.

For motor proficiency, the score increased in the experimental group compared to the control group. These results show the effectiveness of exercise on cognitive and psychological problems in hyperactive children, which is supported by previous studies. Silva et al reported swimming training improves depression and motor skill in children with ADHD [33]. Den Heijer et al. confirmed the impact of different sports on hyperactive children's motor and cognitive skills [34]. This hypothesis was tested via aerobic exercise with music, and the results of this exercise showed a positive effect on motor proficiency, anxiety, depression, and cognitive ability. This exercise may increase physical fitness and other performance variables, such as motor coordination [8].

The result of RCMAS test which was used to evaluate anxiety before and after aerobics training with music in this study, decreased, but this decrease was not significant in the control group. This result suggests that exercise can be used as an intervention program to reduce the problematic behaviors of children with ADHD. Performing aerobic exercises with music reduced anxiety. This effect seems to result in less anxiety speculatively due to group work, the joy of composition of music and exercise, the confidence that results from learning the movements, and secretion of positive affective hormones in the brain [11].

In CES-D test for depressive symptoms, the score decreased from 20.11 to 15.05 points, but this decrease was not significant in the control group. These results show the effectiveness of exercise on cognitive and psychological problems in overactive children, which is supported by previous studies. So et al. reported the positive impact of 4 week horseback riding on anxiety and depression in overactive children aged 10-12 years [9]. Kiluk et al showed that children with ADHD who participated in three or more sports displayed significantly fewer anxiety or depression symptoms than did those who participated in fewer than three sports [35]. Similar to previous studies, this study also showed that the aerobic intervention with music decreased depression and anxiety. This decrease in depression may be due to the physical activity effects on neurotransmitter activity. Serotonin is a neurotransmitter that plays a key role in adjusting mood, such as feelings of hope, enjoying life, adjusting sleep, interest in the job, and several other positive features, which may be influenced by exercise engagement [13].

The result of WISC-IV test, which was used to evaluate cognitive ability, before and after aerobics training with music in this study, showed that working memory, perceptual reasoning, and processing speed increased. But, the control group did not show a significant increase in these variables. Studies of the impact of exercise on

cognitive abilities support our results. Ziereiz, the effect of physical activity intervention on executive function (such as working memory) and motor performance in children seven to twelve years old positive reported [10]. Furthermore, previous study's result indicate that interventions to increase the level of physical activity in children with and without ADHD might improve affect and executive functioning [34]. This study's results confirm the importance of aerobic exercise in children with ADHD [11]. Aerobic exercise with music affects the cognitive ability and release of endorphins to enhance happiness and improve cognitive abilities [13]. The exploratory nature of non-linear pedagogy also helps children's mind involvement and may be another reason for improving the cognitive ability of the study participants.

Robinson et al. indicate that motor competence is positively associated with perceived competence and multiple aspects of health (i.e., physical activity, cardiorespiratory fitness, muscular strength, muscular endurance, and healthy weight status [35]. Regular physical activity increases motor competence, which in turn may augment self-esteem [35]. This is supported by the present study showing improvements in motor proficiency, depression, anxiety, and cognitive ability of overactive children. The control group performed its routine activities, which included various exercises, in a linear manner, and the experimental group performed aerobic exercise in a non-linear manner. This study shows that using the aerobic method in combination with music and the non-linear method is better than the linear method, which is discussed below. In the discussion of combining aerobic exercise with music, it can be said that when exercise is practiced alongside music, children can coordinate the speed of the music and their movements which, in addition to individual coordination, also stimulates the coordination between groups and encourages the person to continue the activity. Another explanation can be the individual's attention to music. When a person is exercising without music, the level of motivation may decline due to physical tiredness, and this fatigue may reduce an individual's ability to continue training. While training with music, one can continue exercising by coordinating their movements with the rhythm of music and ignore disruptive factors, such as fatigue. Thus, music makes people more likely to benefit from the positive effects of physical activity, which improves mood and cognitive ability (like anxiety, depression, working memory, perceptual reasoning, and processing speed), and motor proficiency [13].

In the discussion of nonlinear pedagogy, it can be said that the nonlinear pedagogy considers individual differences, that is, learners' intrinsic dynamics, which help in designing an appropriate practice environment for all learners, including students with ADHD. According to the nonlinear pedagogical approach, practitioners which provide an appropriate practice environment to stimulate learners' exploratory behavior might increase learners' autonomy and self-esteem; hence, this contributes to improving the child's physical activity participation [14]. As such, the nonlinear pedagogy used in aerobic

exercise with music for children with ADHD can foster the physical activity participation of all children, and it is effective to improve motor proficiency, working memory, perceptual reasoning, and processing speed and decreasing anxiety and depression.

This study may open a new perspective to improve the problems of children with disabilities, using aerobic training coupled with music in a nonlinear pedagogy environment. However, it was not possible to evaluate the impact of the intervention of present study on boys and girls, nor was it possible to compare this method with other groups such as aerobics without the music or traditional training methods. Moreover, we did not follow the control group in terms of exercise, and in their routine classes, there was aerobic exercise and other interventions that were performed linearly. Therefore, it is better to compare future studies of linear and nonlinear groups under equal conditions.

Conclusion

Our data suggest that the aerobic training program combined with music in a nonlinear environment reduces anxiety and depression and increases motor proficiency, working memory, perceptual reasoning, and processing speed. This study's results suggest that using aerobic training programs using non-linear pedagogy in schools, clinics and rehabilitation may, potentially, be beneficial for children with ADHD.

Acknowledgment

This paper is based on a research project which has been done by financial and spiritual aids of research affairs at the Kharazmi University of Tehran. Ethics code for this article obtained from Tehran University of Medical Sciences. IR.UT. PSYEDU.REC.1398. 026.

Conflicts of Interest: None declared.

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