

## The Effect of Water Treadmill Exercise on Children with Attention Deficit Hyperactivity Disorder

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### Abstract

#### Background

Attention deficit hyperactivity disorder (ADHD) is one of the prevalent disorders in child psychiatry with the potential of damage to mental talent evolution process and socio-emotional skills. This study aimed to determine the effect of Water treadmill exercise on children with Attention deficit hyperactivity disorder (ADHD).

**Materials and Methods:** This was an experimental study with pretest, posttest design which was done in Gorgan. Participants were 46 children (mean age = 9.45 ±0.5, male = gender) who were identified and selected based on diagnostic criteria in two stages and were randomly divided into experimental and control groups (n=23). The experimental group performed running on a Water treadmill for eight weeks with three sessions each week (24 sessions in total) and each session for 30 minutes. The exercise intensity was for 10 minutes 40-45% and 20 minutes 55-65% of the maximum heart rate reserve. All sessions begin with a brief warm-up, including light aerobic activity and dynamic, static stretching, and end with a cool-down. Disorder Levels were measured using the Conners' Parent Rating Scale-Revised (CPRS-R), and diagnostic interviews. Data were analyzed using SPSS software version 22.

**Results:** The results showed that after controlling the pretest levels, behavior problems, social problems, anxiety-shyness, psychosomatic, and the overall score of attention deficit hyperactivity disorder in the experimental group were significantly lower the posttest than the control group (p<0.05).

#### Conclusion

Based on the results, exercise interventions with Water treadmill for eight weeks effectively reduce the symptoms of attention deficit hyperactivity disorder in children and can be used as an appropriate intervention.

**Key Words:** ADHD, Children, Exercise, Physical Activity, Motor development.

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## 1- INTRODUCTION

Attention deficit hyperactivity disorder (ADHD) is one of the most common childhood disorders. This disorder's prevalence is 7.2% worldwide and between 2 and 18% in Iran (1). Early and timely diagnosis of behavioral problems that manifest themselves in preschool is crucial because almost all mental health professionals emphasize that the early years are essential in later adjustment and the existence of issues during this year is the basis of maladjustment in the coming years. ADHD has many complications and problems, including mood disorders, depressive disorders, antisocial personality disorder, and substance abuse disorders, which can lead to decreased self-esteem and academic achievement and reduced career success (2-4).

Currently, existing treatments for Attention deficit hyperactivity disorder include stimulant drugs and Behavior therapy, and the effectiveness of both methods has been confirmed in the research literature (5). However, these treatments have limitations, for example, stimulant drugs have little effect on academic achievement and communication skills of children with Attention deficit hyperactivity disorder with peers, and about 30% of people do not respond to Stimulant drugs (5). Long-term side effects have not been reported for stimulant drugs, but these drugs have short-term side effects such as insomnia, anorexia, headache, stomach pain, and a slight decrease in heart rate and blood pressure.

The cost and availability of these drugs are low (6), and their short-term side effects have raised concerns about the developmental problems of children with the disorder (7). Despite its desirable effectiveness, behavior therapy is limited due to the difficulty of registration, high cost, and the increased need for family communication with the child (8). Some

studies have reviewed the effectiveness of drug and Behavior therapy and confirmed its positive effects (9), but the high cost of two treatments together and its ineffectiveness in the complete treatment of the disorder make combined therapy expensive and not accessible to all families (7). In the meantime, experts have suggested physical activity as an alternative method that is feasible, sustainable, and acceptable for families and children. In addition to the positive health effects (10), the physical activity effectively improves adolescents' and youngsters' emotional, cognitive, behavioral, and social performance (7).

As mentioned earlier, children with ADHD face deficiencies and diseases that physical activity may reduce and improve the condition. Physical activity positively affects brain function and structure in hyperactive children and adolescents, thereby accelerating neural growth and development, promoting cognitive and inhibitory control, and thus may Improve Attention deficit hyperactivity disorder symptoms (11). According to studies, five potential factors may moderate the association between physical activity and its effects in children with Attention deficit hyperactivity disorder. Physical activity on Attention deficit hyperactivity disorder is influenced by the type, intensity, length, and frequency of sessions and duration of physical activity interventions (7).

In previous studies, the effect of different types of physical activity on ADHD has been investigated (7, 12-15). In some of them, aerobic physical activity has been more effective than other types of physical activity. In a meta-analysis of the effects of physical activity on children's cognitive development and outcomes, Fedewa and Ahn (15) found that aerobic, cognitive-motor, and general physical exercise significantly affected these indicators. However, the impact of aerobic exercise on cognitive outcomes was considerably

more significant than the others. In a quantitative review of 22 studies examining the effects of physical activity in children with Attention deficit hyperactivity disorder, Conlius et al. (7) found that experimental groups had, on average, 59% more positive outcomes than those in the study group. Also, the experimental groups participating in physical activities had 42% less emotional and mood problems and 49% fewer internalization problems compared to the control groups; However, according to this study, physical activity did not have a significant effect on attention, social issues, performance, motor skills, and academic achievement. In terms of exercise characteristics, only the effectiveness of aerobic exercise-based interventions was confirmed; Experimental groups reported 39% more positive outcomes. Also, there was no difference between the interventions' effectiveness for intensity, length, and frequency of sessions, and duration of the course (7).

Hydrotherapy and Water aerobics have grown significantly in the last two decades due to their benefits. This method can be used as a therapeutic and non-pharmacological method for many diseases. The properties of water are hydrostatic and thermodynamic pressures that allow a person to exercise in a safe and pain-free environment (16). For example, the buoyant force acts against gravity, which can act as an auxiliary, resistance, or support force, and the aquatic environment can provide easy movement for children in the water. Hydrostatic pressure creates a kind of resistance exercise condition and provides a sense of stability, and makes children more active. Aquatic activities are used to create physiological benefits such as strength, coordination, range of motion, perceptual and spatial awareness, muscular and cardiovascular endurance, and relaxation (17). One equipment that can

realize the benefits of Water aerobics is the Aqua Treadmill. One of the significant and essential advantages of using an Aqua treadmill is that in exercising with this device, all the limitations people face in aerobic exercise are removed. The possibility of sports activities for all people of any age and any physical fitness level is eliminated. One of the limitations that people face in aerobic exercise and treadmill is that the pressure exerted in these exercises can lead to cramps and injuries and exacerbate joint wear and tear in some instances, such as people with chronic joint disease and obese people and the elderly, and this makes these people unable to do such sports activities.

Compared to a standard treadmill, while running or walking on an Aqua Treadmill, despite the low adverse effects of the environment, a patient bears only 20% of his weight, which relieves pressure on the joints (18). Given the importance of effective treatments for hyperactive children, the effects of Water aerobics have not yet been investigated, therefore the present study aimed to answer the question of whether exercise with a water treadmill has an effect on attention deficit / hyperactivity disorder in children.

## **2- MATERIALS AND METHODS**

### **2-1. Study design and population**

This was an experimental study with pretest, posttest design which was done in 2020 in Gorgan, North of Iran. The participants of the study were 46 children (mean age =  $9.45 \pm 0.5$ , male = gender) who were identified and selected based on diagnostic criteria in two stages and were randomly divided into experimental ( $n = 23$ ), and control ( $n = 23$ ) groups. The first two sheets were arranged, and the name of the experimental and control group was written on each sheet, and then two codes were selected each time by drawing from the container which contained 46 test codes and randomly registered in one of

the sheets. The sample size was determined by referring to Cohen's table to choose the sample size in experimental studies, and the sample size for each group was 20 people by considering the effect size of 0.7, test power of 0.91 and significance level of 0.05, and by 23 people were evaluated for each group regarding the probability of participants drop out. To identify the participants, the indicators of Attention Deficit Hyperactivity Disorder were first explained to teachers based on the Conners' Parent Rating Scale (CPRS), and suspected students were identified.

The identified students were then asked to deliver a sealed package to their parents containing a complete description of the objectives, content, and timing of the research program, the researcher's contact information for possible questions, the consent form and personal information, and the Conners' Parent Rating Scale-Revised (CPRS-R), and a guide to its completion. Then, the returned questionnaires were analyzed, and 50 children who had a high score in the dimensions of attention deficit hyperactivity disorder were identified (high scores above two on the range of zero to three). In a telephone call with the parents, they were asked to come to the psychologist's office according to the diagnostic clinical interviews schedule. Finally, 46 students were selected and placed in experimental and control groups.

## 2-2. Assessment Tools

**2-2-1. Conners' Parent Rating Scale-Revised (CPRS-R):** For the first time, Conners (20) presented the main form of this scale in the form of a 39-item version for teachers and a 93-item version for parents. In 1978, Goyt et al. (21), created a short form of the scale based on factor analysis of data from 570 children aged 9 to 11 in St. Petersburg. The short form of this scale contains 48 items on five subscales consisting of behavior problems, learning difficulties, psychosomatic problems, impulsive hyperactivity, and anxiety passivity (**Table.1**); and its answers are on a four-point Likert scale from zero (strongly disagree / never / Rarely) up to three (strongly agree / often / almost always), and completed by the child's parents (**Table.1**).

In Iran, Shahaian et al. (22) validated the Persian version of this scale in a sample of 598 children. Based on factor analysis, four factors of behavior problems, social problems, anxiety-shyness and psychosomatic were identified for this scale. The retest reliability coefficient for the total score was equal to 0.58 and from 0.41 for the subscale of social problems to 0.76 for the subscale of behavior problems. Cronbach's alpha coefficients for the total score were 0.73 and ranged from 0.57 for the social issues subscale to 0.86 for the anxiety-shyness subscale (22).

**Table-1:** The items that make up the scale subscale.

| Subscale          | Item   | Minimum | Maximum |
|-------------------|--|---------|---------|
| Social problems   | 3-10-17-18-30-31-37-38-39-47                   | 0       | 30      |
| Behavior problems | 2-11-13-14-15-19-20-23-25-27-28-29-34-35-36-46 | 0       | 48      |
| Psychosomatics    | 9-11-13-24-40-41-42-43-44-48                   | 0       | 30      |
| Anxiety-shyness   | 7-8-16-21-26-32                                | 0       | 18      |

**2-2-2. Clinical Interview:** In the present study, an organized clinical interview was conducted by a clinical psychologist based on the criteria of the fifth edition of the

Diagnostic and Statistical Manual of Mental Disorders (23) for Attention Deficit Hyperactivity Disorder. Participants who met the diagnostic

criteria were included in the final sample of the study. The purpose of this interview was to evaluate and accurately diagnose Attention deficit hyperactivity disorder.

**2-2-3. Water treadmill device:** Sabegi (24) made this machine in 2018. This device with a water chamber can easily create a suitable environment for the user to run, walk and conduct hydrotherapy. First, the person enters the chamber to use the device, and after closing the chamber door, the start button is pressed, and water enters. When enough water enters the chamber, the start button is pressed, and the belt starts to move. The relevant expert adjusts the type and amount of speed based on the client's body's ability and physiology. The water level was also adapted to the top of the person's knee.

### 2-3. Intervention

The study's experimental period consisted of 8 weeks and three sessions per week (24 sessions in total), and each session lasted for 30 minutes. The exercise included running on an Aqua treadmill, the intensity of which was 10 minutes with 45-40% and 20 minutes with 55-65% of the maximum heart rate reserve. All sessions begin with a brief warm-up, including light aerobic activity and dynamic, static stretching, and

end with a cool-down. This exercise protocol was confirmed in previous research (19). The control group did not participate in any organized physical activity. According to the pretest, one week after the end of the experimental period, parents were asked to complete the Conners' Parent Rating Scale-Revised.

### 2-4. Ethical Considerations

For ethical considerations, the researchers received written consent from the participants' parents for participation in the research.

### 2-5. Data Analysis

Analyze of Covariance was used to analyze the data. The data were analyzed in SPSS software version 22.0. In all analyzes, the significance level was  $p < 0.05$ .

## 3- RESULTS

The study started with 46, and 5 participants (3 in the experimental group and 2 in the control group) withdrew from the study. Therefore, to test the research hypotheses, the data of 40 people were analyzed (20 experimental groups, 20 control groups). Baseline characteristics of participants demonstrated in **Table.2**.

**Table-2:** Baseline characteristics of the participants.

| Groups       | Age (years)<br>(Mean± SD) | Weight (kg)<br>( Mean± SD) | Height(cm)<br>(Mean± SD) |
|--------------|---------------------------|----------------------------|--------------------------|
| Experimental | 9.6±0.5                   | 31.5±4.3                   | 135.5±8.5                |
| Control      | 9.5±0.3                   | 30.8±4.1                   | 134.5±7.9                |

The results of Kolmogorov-Smirnov test showed that the distribution of data related variables has a normal distribution ( $p > 0.05$ ). After examining the assumptions of analysis of covariance, five series of analysis of covariance were used for intergroup comparisons in which the group variable (experimental / control) as an independent variable, the number of social

problems, behavior problems, psychosomatic, anxiety-shyness, and overall attention score / hyperactivity was considered as dependent variables and pretest values of the variables were considered as a control variable. The results of these analyzes are presented in **Table.3**. The results of research on social problems showed that after controlling the

effect of the pretest, the impact of the group on social issues is statistically significant ( $\eta^2 = 0.154$ ,  $p=0.008$ ,  $F=1.37F$ ), meaning that there is a significant difference between the experimental and control groups in the posttest. Also, the results of research on behavior problems showed that after controlling the effect of the pretest, the impact of the group on behavior problems is statistically significant ( $\eta^2 = 0.162$ ,  $p=0.003$ ,  $1.37$ ,  $F=24.24$ ), meaning that there is a significant difference between the experimental and control groups in the posttest. Also, the psychosomatic results showed that after controlling the effect of the pretest, the impact of the group on the psychosomatic was statistically significant ( $\eta^2 = 0.136$ ,  $p=0.024$ ,  $1.37$ ,  $F=5.65$ ), meaning that there is a significant difference between the experimental and control groups in the posttest. Also, the results of anxiety-shyness showed that after controlling the effect of the pretest, the impact of the group on anxiety-shyness was statistically significant ( $\eta^2 = 0.124$ ,  $p=0.017$ ,  $1.37$ ,  $F = 5.78$ ), meaning that there is a significant difference between the experimental and control groups in the

posttest. Also, the results of the overall score of attention/hyperactivity showed that after controlling the effect of the pretest, the impact of the group on attention/hyperactivity is statistically significant ( $\eta^2 = 0.23$ ,  $p=0.001$ ,  $F=1.374$ ), meaning that there is a significant difference between the experimental and control groups in the posttest. Considering the mean values of the groups in the posttest, it can be concluded that the score of social problems, behavior problems, psychosomatic, anxiety-shyness, and the overall score of attention/hyperactivity in the experimental group is significantly lower than the control group. In other words, the Water treadmill exercise had a significant effect on social problems, behavior problems, psychosomatic, anxiety-shyness, and children's overall attention/hyperactivity score. ETA also indicates that 15% of the reduction in social issues, 16% of the decrease in behavioral problems, and 13% of reduction in psychosomatic, 12% of the decrease in anxiety-shyness, and 23% of reduction in the overall score of attention/hyperactivity in children is derived from the effect of Water treadmill exercise.

**Table-3:** Descriptive statistics of research variables and summary of covariance analysis results.

| Variables         | Phase     | Experimental (n=20) | Control (n=20)   | F    | P-value | $\eta^2$ |
|-------------------|-----------|---------------------|------------------|------|---------|----------|
|                   |           | Mean $\pm$ SD       | Mean $\pm$ SD    |      |         |          |
| social problems   | Pretest   | 16.5 $\pm$ 2.3      | 15.8 $\pm$ 2.5   | 6.85 | 0.008   | 0.154    |
|                   | Post-test | 12.4 $\pm$ 2.1      | 16.1 $\pm$ 2.2   |      |         |          |
| Behavior problems | Pretest   | 25.55 $\pm$ 3.45    | 24.54 $\pm$ 3.2  | 7.24 | 0.003   | 0.162    |
|                   | Post-test | 19.2 $\pm$ 3.2      | 24.12 $\pm$ 3.8  |      |         |          |
| Psychosomatics    | Pretest   | 17.42 $\pm$ 4.5     | 16.88 $\pm$ 3.9  | 5.65 | 0.024   | 0.136    |
|                   | Post-test | 14.25 $\pm$ 3.8     | 17.01 $\pm$ 3.52 |      |         |          |
| Anxiety-shyness   | Pretest   | 8.55 $\pm$ 1.52     | 8.24 $\pm$ 1.62  | 5.78 | 0.017   | 0.124    |
|                   | Post-test | 6.24 $\pm$ 1.23     | 8.32 $\pm$ 1.58  |      |         |          |
| Overall score     | Pretest   | 67.55 $\pm$ 8.5     | 68.22 $\pm$ 7.95 | 9.54 | 0.001   | 0.23     |
|                   | Post-test | 54.64 $\pm$ 9.2     | 69.12 $\pm$ 8.13 |      |         |          |

SD: Standard Deviation.

#### 4- DISCUSSION

This study aimed to determine the effectiveness of Water treadmill exercises in children with Attention deficit hyperactivity disorder. The results showed that eight weeks of Water treadmill exercise significantly affected children with Attention deficit hyperactivity disorder, including social problems, behavior problems, psychosomatic, anxiety-shyness, and reduced them to the control group. Eta squared also showed that 15% of the reduction in social issues, 16% of the decline in behavior problems, 13% of the decrease in psychosomatic, 12% of the decrease in anxiety-shyness, and 23% of the reduction in the overall score of attention/hyperactivity in children is derived from Water treadmill exercise.

Consistent with the findings of the present study, various studies have used a variety of physical activities and supported the effectiveness of exercise courses to reduce Attention deficit hyperactivity disorder, including developmental exercises(13), perceptual-motor and resistance-balancing practices(14), yoga exercises (25), aerobic exercises (26, 27), selected exercises (28), anaerobic exercises (29).

According to Conlius et al. (7), physical activity courses produce an average of 59% more positive outcomes for the experimental groups than for the control groups. Also, experimental groups participating in physical activity experience 42% less emotional and mood problems and 49% fewer internalization problems compared to control groups; However, according to this study, physical activity has no significant effect on attention, social issues, performance, motor skills and academic achievement (7), which is inconsistent with the findings of the present study. In the research literature, the central part of the positive effects of physical activity on Attention deficit hyperactivity disorder has been attributed to the brain's structural and

physiological adaptation. Studies show that the brain development of children with Attention deficit hyperactivity disorder is slower than that of their peers (30), and that serum levels of the brain-derived neurotrophic factor are lower in children with the disease (31). Brain-derived neurotrophic factor is involved in the regulation of synaptic plasticity (one of the most important physiological processes involved in learning) and neurogenesis (30), and based on available evidence, sequential aerobic exercise (three 45-minute sessions for 12 weeks to five 60-minute sessions for six months, with an intensity of 60 to 90% of maximum oxygen consumption or 50 to 75% of maximum heart rate) increases brain-derived neurotrophic factor (32, 33).

Children with Attention deficit hyperactivity disorder with blindfolded balance, bilateral motor coordination, accuracy, and hand movements speed are lower than normal children. They are involved in motor planning, control, sensory integration, and sensory processing, all with problems that can be improved by physical exercises (34). The present study findings can be attributed to some hormone-like substances that relaxes the body, thereby reducing hyperactivity. Studies on the body's metabolism show that exercise positively affects the brain's neurochemical part and stimulates the brain, for example, by increasing dopamine. Increased dopamine receptors' sensitivity in response to dopamine secretion due to exercise can reduce ADHD (35, 36). It has also been reported that aerobic exercise due to adaptation reduces the secretion of norepinephrine and cortisol and increases hormone-like substances such as endorphins, and increases serotonin's reabsorption in the brain, which plays an essential role in reducing attention deficit and hyperactivity. Exercise reduces the potential for action in the heart's sinoatrial

node by modifying physiological changes, such as regulating the cardiovascular system, primarily affecting the parasympathetic nervous system and stimulating the vague nerve. A decrease in impulsivity can also be expected (36, 37). The problems of children with Attention deficit hyperactivity disorder are six times more common with their classmates than children without behavioral-emotional problems and ten times more common in everyday life (family, friendships, and learning) than normal children (38). Games and sports activities reduce attention deficits by making physiological changes such as regulating the cardiovascular system, primarily affecting the parasympathetic autonomic nervous system and vague nerve stimulation, which can also minimize impulsivity (39).

One of the effective mechanisms in reducing Attention deficit hyperactivity disorder syndrome is the child's achievement of more desirable physical-motor abilities through physical exercise and, consequently, increase the motivation to be active in the group. Exercise and physical activity are potent stimulants for the hypothalamic, mucosal-adrenal, pituitary, and noradrenergic systems. Physical exercises and sports activities positively affect movements, planning, scheduling, working memory, interlimb coordination and concentration, and attention (40). One of the requirements for effective and coordinated movement is appropriate muscle tone, plan training, and sensory feedback from practice in the environment to modify the movement plan. Children with Attention deficit hyperactivity disorder have low muscle tone, which leads to weakness in the deep and balance systems and leads to weakness in motor skills. These children's problems can be prevented by the exercise and practice of sports activities in schools (41). According to the findings of this study, it can be concluded that eight weeks of

training with a Water treadmill is effective in reducing the symptoms in children with Attention deficit hyperactivity disorder. These findings point to the role and importance of exercise and regular and organized physical activity in the prevention and treatment of behavioral diseases in children as a non-invasive and non-pharmacological method and emphasize its necessity given the industrial conditions prevailing in human societies. As a limitation of the present study, it can be said that the research results were limited to boys, so the generalization of the results to the male children community can be generalized. Also, the participants in this study had an average age of ten years, so we should care in generalizing the results to other age groups. It is suggested that this study should be performed in a female population. Also, the effect of different exercise methods should be studied on Attention deficit hyperactivity disorder.

## 5- CONCLUSION

According to the findings of this study, it can be concluded that eight weeks of exercise with a water treadmill reduces the symptoms and signs of children with ADHD. These findings point to the role and importance of exercise and regular and organized physical activity in the prevention and treatment of behavioral disorders in children as a non-invasive and non-pharmacological method and emphasize its necessity given the industrial conditions prevailing in human societies.

**6- CONFLICT OF INTEREST:** None.

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