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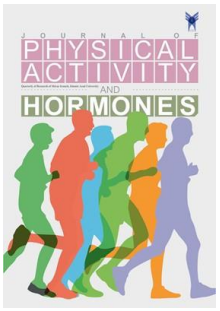

The positive effect of high-intensity interval swimming on motor performance in rats with Parkinson's disease model

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Abstract

Introduction: The effect of swimming on the behavioral complications of Parkinson's disease has been investigated recently. However, based on our research, accurate and reliable information is still not available to clarify the effect of this type of exercise. So, the present study was designed to investigate the effect of high-intensity interval swimming on improving performance in rats with Parkinson's disease models.

Material & Methods: In this experimental study, twenty-one 8-week-old male Wistar rats (weight 200±10.2 grams) were divided into three equal groups, including healthy control (HCG), Parkinson control (PCG), and swimmer Parkinson group (SPG). Parkinson's disease was induced through intraperitoneal injection of reserpine for 5 consecutive days in both of the rats (PCG and SPG) groups and the rats in the SPG performed high-intensity interval swimming according to the training protocol for 6 weeks. Catalepsy behavior was measured with bar test. Data were analyzed using one-way ANOVA and LSD post hoc test through SPSS software (version 22) at $P<0.05$.

Results: Based on the result of the Shapiro-Wilk test, the distribution of data in the present study was normal. There was a significant difference in the time of the bar test between the HCG and the PCG ($P<0.05$). There was also a significant decrease in the time of the bar test in SPG with both HCG and PCG ($P<0.05$).

Conclusion: In general, the findings of the present study showed that swimming training could significantly improve the motor disorder in rats with Parkinson's disease. The results also showed the beneficial effects of high interval swimming training on the improvement of motor activity (catalepsy behavior) in rats.

1. Introduction

Catalepsy is a behavioral state of muscular rigidity that is associated with Parkinson's disease (1). Catalepsy can be observed in rodents when they are placed in an abnormal position and remain in this position for a prolonged period of time which is related to decreased dopamine (DA) transmission at postsynaptic receptors (2). The typical test for measuring catalepsy is the bar test which consists of placing a rat's forepaws on an elevated bar with the hind paws remaining on the floor. The time recorded for the rat to correct this posture is an index of the intensity of catalepsy. A cataleptic rat will continue to hold onto the bar for a prolonged period of time while a normal rat will change its position within seconds (2).

Although exercise training has been introduced as a simple, low-cost and minimal means of treating Parkinson's disease, the mechanisms are not still well known (3) Parkinson's disease is one of the types of diseases that have been widely investigated by sports science researchers in recent years. People with Parkinson's disease experience movement disorders and muscle imbalance; therefore, due to the reduction of muscle efficiency, these people gradually

experience muscle weakness and rigidity as well (4). The result of one study have shown that exercise training can exert its positive effects on patients with Parkinson's disease by changing the dopaminergic system, glial-derived neurotrophic factors, modulating inflammation in neurons and improving neurogenesis (5). According to the results of the previous study, swimming could improve movement disorders in rats with Parkinson's models (6). Besides, the effect of forced swimming was evaluated on oxidative stress and inflammation in rats with Parkinson's model; results showed that this type of swimming could improve anti-oxidant defense and control level of information in rats with Parkinson's disease (7). Moreover, the effect of eight weeks of hydrotherapy on lower limb muscle strength in patients with Parkinson's disease was investigated by Azizi et al.(2014). The result of this study indicated the improvement of lower body muscle strength in these patients. Therefore, it can be said that swimming as one of the types of resistance exercises may be effective as a factor for muscle strengthening in patients with Parkinson's disease (8). In addition, researchers designed a semi-experimental study with a pre-test and post-test method with a control group. This study aimed to investigate the effect of hydrotherapy on the balance of patients with Parkinson's disease. The results showed that hydrotherapy could be applied as a useful and effective treatment method to improve balance and subsequently improve the daily performance of patients (9). Meanwhile, to investigate the possibility of drowning in water in people with Parkinson's disease, a study was designed in 2018; the main goal was to evaluate the frequency of changes in swimming capacity after the onset of the disease. After evaluating the results of the questionnaires, tremor was reported as the first complaint in 44% of patients. 90% of participants in this study were able to swim before the onset of Parkinson's disease symptoms. Among people who were able to swim, 87.7% noted a change in their swimming performance after illness onset, and 49.1% reported a drowning or near-drowning episode. 36.5% of the participants reported respiratory problems during swimming and 34.9% of the people noted their lower limbs as the main cause of their problems. In general, based on the results collected from this study, the most common reasons for stopping swimming were difficulty in coordinating movements and buoyancy. The results of this research showed that Parkinson's disease can seriously interfere with the capacity and ability to swim (10).

In general, according to our research and an overview of previous studies on the effect of swimming in improving movement performance in patients with Parkinson's disease, there are still many uncertainties in this matter; therefore, more research is needed in this field. So, we decided to design this study to investigate the effect of high-intensity interval swimming on improving behavioral performance in rats with Parkinson's disease models.

2. Methodology

2.1. Materials and methods

The method of the present study was experimental.

2.2. Participants

In this experimental study, 21 male Wistar rats (age, 8 weeks and weight, 200±10.2 grams) according to the rules of estimating the sample size based on the degree of freedom (df = 18) and the number of groups (n = 3) is considered (11). The samples were obtained from the laboratory animal breeding and reproduction center of Islamic Azad University, Shiraz branch, and were transferred to the animal laboratory of this university. Animals were kept at standard temperature (22-24°C), 45% humidity, 12-12 light-dark cycles (8 am to 8 pm), and in plastic cages covered with sawdust. It should be said that, during this study, the animals had free access to water and food and were moved by an expert during the entire research period. While observing the Helsinki Convention throughout the research period, the research procedures were approved by the Ethics Committee of Shiraz Branch, Islamic Azad University, and it was registered with number IR.IAU.SHIRAZ.REC.1402.054. Rats were kept in laboratory conditions for one week so that the animals got familiar with the new environment.

2.3. Measurements

One day after the end of the disease induction period, a rotation test was applied among rats in all 3 groups randomly to confirm the Parkinson's disease model. In this test, about 2 cm above the place where the tail joins the body of the rat was taken and the rat was raised so that the animal's nose was placed 2 cm above the support surface. If the rat could not maintain its balance and began to turn to both sides, it was considered as a sign of induction of Parkinson's (13).

2.4. Intervention

21 rats were divided into 3 equal groups of 7 (HCG, PCG, and SPG). Then, Parkinson's disease was induced by intraperitoneally injecting 1 mg of reserpine (manufactured by Sigma-Aldrich, India) per kilogram of body weight into 14 rats in PCG, and SPG for five consecutive days with a regular schedule (12). To prepare reserpine, the desired amount of reserpine was dissolved in 0.03 ml of glacial acetic acid solution and then the solution was made up to volume using distilled water.

One week before the start of the main training protocol, rats in the SPG were introduced to the animal pool (diameter 160 cm and height 80 cm). A day before the start of the research, the rats of the swimming group were carefully and calmly placed in the animal pool and swam at the desired speed for five minutes. In the next sessions and after enough familiarization with swimming, to get familiar with the type of interval swimming, the rats were taken out of the water several times after swimming for one minute by the resting plate and then put back in the water. After completing the familiarization period, the intense interval swimming protocol was performed for six weeks, 3 sessions per week. It should be said that the working load applied in the first week was a weight equal to seven percent of the body weight of each rat, which was tied to their tail and added to its weight by one percent every week; so that, in the last week (sixth week), rats performed swimming with a weight of 14% of their body (14). After every single swimming session, the rats were dried with a towel and transferred to the holding place. During the study period, the samples of the HCG and PCG did not have any intervention. Finally, 48 hours after the last training session, to investigate the effect of swimming on the performance of the rats, the bar test was performed in all 3 research groups.

2.5. Statistical Methods

The Shapiro-Wilk test was applied to check the normal distribution of data. Since the data had a normal distribution, to examine the changes in the studied variables, one-way ANOVA and LSD post hoc tests were applied through SPSS software (version 22). The minimum significance level was $p<0.05$ in all tests

3. Results

The distribution of data in the present study was completely normal. So, we used one-way ANOVA to check the differences between groups. LSD was used as well in this research. The results are reported in Table 1 and Figure 1.

Table 3. *The result of the bar test in different research groups (n=7 in each group)*

Group Name	Mean second	Std. Error	95% Confidence Interval	
			Lower Bound	Upper Bound
PCG	97.245	6.421	84.071	110.419
HCG	40.063	6.421	26.889	53.238
SPG	7.724	5.944	-11.473	12.921

Healthy Control (HCG), Parkinson Control (PCG), and Swimmer Parkinson Group (SPG)

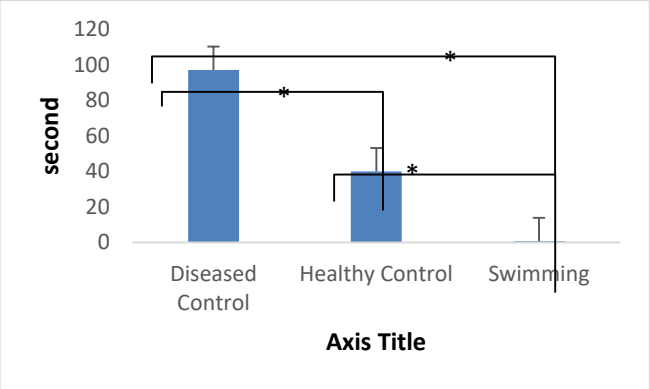

Figure 1. *Catalepsy test (Bar test) in different research groups*
**Significant difference level (P<0.05)*

As it can be seen in the Figure 1, there was a significant difference in the time of bar test between HCG and PCG ($P<0.05$). So, LSD test was done as a post hoc statistical test. Figure 1, was shown a significant decrease in the time of bar test in SPG with both PCG and HCG ($P<0.05$).

4. Discussion

The results of the present study showed that 6 weeks of high-intensity interval swimming practice significantly decreased the mean time of catalepsy. It is worth mentioning that this type of exercise training with the mentioned intensity could significantly improve rats' motor coordination by reducing their motor disorder and muscle stiffness.

Parkinson's disease is caused by damage to the nervous system. Doing appropriate exercise training have protective effects on the nervous system (15). Therefore, the present study designed to evaluate the effects of high-intensity interval swimming on Improving Motor Performance in Rats with Parkinson's disease Model. According to the previous study, four weeks of swimming could significantly improve the motor disorders in Parkinson's disease model. Moreover, four weeks of swimming showed a significant increase in motor balance test. So, it can be considered as an effective treatment for preventing the multiple complications of Parkinson's disease (15). It has been reported that exercise and physical activity could improve the performance of muscular nervous system and anatomical adaptations, break down the negative cycle of disease, aging, and immobility through exerting positive effects on dopamine levels that caused to improve the performance of patients with Parkinson's disease (16). Dopamine increases the activity of the direct path and motor activity and decreases the activity of the indirect path in the corpus striatum (17). Animal studies have also shown that daily exercise leads to the release of various neurotransmitters in the brain like dopamine (18). On the other hand, physical exercise could increase the activity of endogenous antioxidant system in the brain and regulates the reduction of glutamate receptors that contribute to stimulatory toxicity (19). In this regard, researchers have argued that exercise can increasingly elevate the survival rate, resistance to brain damage, and hippocampal nerve growth (15; 20). Similar with these results, Viosoicovik et al. (2010) investigated the effect of a high-intensity exercise on treadmill on rats with the Parkinson's disease. The results showed that high-intensity treadmill exercise increased the production of dopamine receptor in the corpus striatum. Dopamine receptor specifically causes the transport of dopaminergic neurotransmitters and supports motor performance in the corpus striatum (21). Exercise in water can also be used as a useful and effective therapeutic approach to improve the muscle strength of the lower part of the body in patients with Parkinson's disease (9). Moreover, results of Tajik et.al. (2023) showed that swimming could improve movement disorders in rats with Parkinson's model (6). In addition, results of Keshavarzian et.al. (2021) indicated that the effect of forced swimming evaluated on oxidative stress and inflammation in rats with Parkinson's model; results showed that this type of swimming could improve anti-oxidant defense and control level of information in rats with Parkinson's disease (7). Accordingly, exercise programs may be able to delay or reverse functional disorders in patients with Parkinson's disease. Exercise can improve the physical performance, quality of life, muscle strength, and balance caused of this disease (22). In any case, it can be concluded that exercise programs improve the balance by affecting other physical factors as well as changing the mechanisms involved in the balance. Performing exercise therapy movement along with common medical treatments can have a positive effect on the motor performance and quality of life in patients with Parkinson's disease, which is useful for these patients (23). Current results demonstrated that high interval swimming exercise improved catalepsy behavior in rat. For a more comprehensive understanding of the effects of intensive exercise, future experiments should investigate the functional and structural effects of spontaneous motor activity.

5. Conclusion

In general, the findings of the present study showed that swimming practice could significantly improve the motor disorder in rats with Parkinson's disease. The results also showed the beneficial effects of high interval swimming training on the improvement of motor activity in rats.

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This article is part of a Ph.D. thesis and has been recorded by the Principles of Research Ethics Working with Animal license. In doing so, the authors sincerely appreciate and thank all those who have collaborated in this research.

Conflict of interests: The authors declare that they have no conflict of interest relating to the publication of this manuscript.

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