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Comparison of the Effect of Exercise Types on Perceptual-Motor Performance in Boys with Down Syndrome

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A B S T R A C T

Objective: This study aims to compare the effect of exercise types on perceptual-motor performance in boys with down syndrome.

Materials and Methods: Thirty boys with Down syndrome, aged 7 to 14 years, were randomly assigned to three groups: Experimental Group 1, Experimental Group 2, and a Control Group. The training program for Experimental Group 1 lasted 60 minutes, consisting of 10 minutes of warm-up exercises, including light jogging in place, stretching, and dynamic exercises, followed by 30 minutes of aerobic exercise, 15 minutes of resistance training, and a 5-minute cool-down with light stretching. The training program for Experimental Group 2 also lasted 60 minutes, comprising 10 minutes of warm-up exercises, including light jogging in place, stretching, and dynamic exercises, followed by 30 minutes of resistance training, 15 minutes of aerobic exercise, and a 5-minute cool-down with light stretching. Participants were advised to refrain from engaging in any other physical activities during the 6-week training period.

Findings: In the analysis of the interaction effect between group and time, although body mass index (BMI) decreased in both training groups, the difference was not statistically significant ($p > .05$). However, a significant difference was observed in the interaction effect between group and time for gross motor skills, fine motor skills, and upper limb coordination in both training groups ($p < .05$).

Conclusion: Aerobic and resistance training can be considered effective methods for improving BMI and perceptual-motor performance in boys with Down syndrome. The findings, in addition to confirming the importance of this therapeutic approach, may contribute to the development of comprehensive intervention programs aimed at enhancing the quality of life for individuals with Down syndrome.

Keywords: *Down syndrome, aerobic exercise, resistance training, body mass index, perceptual-motor performance.*

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1. Introduction

Down syndrome is an autosomal disorder caused by an extra copy of chromosome 21, known as trisomy (1-3). Down syndrome, or trisomy 21, is one of the most common chromosomal disorders. As a result of this disorder, individuals experience developmental and neurophysiological problems (4). Children with Down syndrome have fewer problems compared to children with other disabilities; however, they face more challenges compared to typically developing children (5). Individuals with Down syndrome have significantly lower physical fitness, are less active, more obese, and have considerably poorer perceptual-motor skills compared to their non-Down syndrome peers (6). Common features among individuals with Down syndrome include muscle hypotonia and joint laxity. Muscle weakness in the lower limbs, along with poor balance when standing, increases the risk of falling in this population (7). Various studies have shown that these individuals engage in less physical activity compared to the general population and even other individuals with intellectual disabilities (8). The sequence of motor skill development in children with Down syndrome does not differ from that of typically developing children; however, the development of these skills is delayed and uneven, resulting in later acquisition compared to typically developing peers (9). The level of physical activity in individuals with Down syndrome is lower and tends to decline more rapidly over time than in individuals without Down syndrome, leading to an increased risk of metabolic diseases and obesity (10). Regardless of the primary cause of obesity in individuals with Down syndrome, it is evident that obesity causes numerous complications and problems for this segment of the population. One of the most significant issues faced by obese individuals is a decline in their motor skill levels (11). The motor impairments in children with Down syndrome also lead to various problems, reducing their independence in performing daily life activities (12). Several studies have reported that aerobic exercise programs designed for individuals with Down syndrome have yielded various benefits, including improvements in functional capacity, work performance, oxidative damage, and low-grade systemic inflammation (13). In contrast, resistance training for this population, despite the beneficial effects of muscle strength on daily functional tasks in adults with Down syndrome, has received far less attention (14). In a study by Seron et al. (2014) comparing the effects of two exercise programs, aerobic and resistance, on body composition in young individuals with Down syndrome, there was no significant change in body fat percentage in either exercise group; however, the control group showed a significant increase in this variable (15). Thus, there is insufficient evidence to determine which exercise program is more effective in improving body composition in individuals with Down syndrome. Given the above points, experimental research on the effects of various exercise methods on body mass index and motor performance in individuals with Down syndrome is crucial. Furthermore, since there is limited research on the impact of aerobic and resistance training on body mass index and motor performance in individuals with Down syndrome, further studies are necessary to enhance understanding of the effects of these exercises on body mass index and motor performance. Therefore, this study examined the effects of aerobic and resistance training on body mass index and motor performance in boys aged 7 to 14 years in Tehran.

2. Methods and Materials

2.1 Study Design and Participants

The present study is a quasi-experimental research with a pre-test and post-test design. Additionally, this study is considered applied research in terms of its practical outcomes. The statistical sample consisted of 30 boys with Down syndrome, aged 7 to 14 years, who were randomly assigned to three groups: Group 1 (primarily aerobic training, n = 10), Group 2 (primarily resistance training, n = 10), and Group 3 (control, n = 10). Body mass index (BMI) was measured before and after the 6-week intervention, and the Bruininks-Oseretsky Test of Motor Proficiency was used to evaluate the participants' perceptual-motor performance.

For the pre-test, the height and weight of the boys were measured to calculate their BMI. The short form of the Bruininks-Oseretsky Test of Motor Proficiency was used, which has demonstrated validity and reliability, with a test-retest reliability coefficient of .78 and an internal consistency coefficient of .86 (Deitz et al., 2007). The obtained data were recorded. The two types of exercise programs, aerobic and resistance, were then implemented. For the post-test, the Bruininks-Oseretsky Test of Motor Proficiency was administered again, and BMI was recalculated. The pre-test and post-test data were compared to determine which type and intensity of exercise had the most significant impact on BMI and motor performance in boys with Down syndrome.

2.2 Training Protocols

The training program consisted of 6 weeks of aerobic and resistance exercises, conducted three sessions per week, with each session lasting 60 minutes. Each session for Group 1 included 10 minutes of warm-up exercises, such as light jogging in place, stretching, and dynamic exercises, followed by 30 minutes of aerobic exercise, 15 minutes of resistance training, and 5 minutes of light stretching for cool-down. Each session for Group 2 involved 10 minutes of warm-up exercises, followed by 30 minutes of resistance training, 15 minutes of aerobic exercise, and 5 minutes of light stretching for cool-down.

Aerobic training was conducted at 50% of maximum heart rate for 10 minutes in the first week, increased to 15 minutes at the same intensity during weeks 2 and 3, and then raised to 60–70% of maximum heart rate for 15 minutes in week 4, and maintained for 30 minutes at the same intensity in weeks 5 and 6 (16, 17). Resistance training involved five stations with 10 repetitions in one set during week 1, two sets during weeks 2 and 3, and increased to seven stations with 12–15 repetitions in two sets during weeks 4, 5, and 6, with a 2-minute rest interval between sets. The stations included exercises such as bicep curls, squats, sit-ups with bent knees, split squats, lat pulldowns, push-ups, and step-ups on a 30-cm step while holding a dumbbell (15, 18). Participants were instructed to refrain from engaging in any other physical activities during the 6-week intervention period.

2.3 Data Analysis

Descriptive statistics (mean ± standard deviation) were used to describe the findings in the control, aerobic, and resistance training groups. Inferential statistics were then applied to test the research hypotheses. The Kolmogorov-Smirnov test was used to verify the normality of the data distribution, and since the results confirmed normal distribution ($p > .05$), parametric tests were employed. A two-way analysis of variance (ANOVA) was used to compare intergroup changes (among control, aerobic, and resistance training groups). If significant differences were found between groups, a one-way ANOVA was conducted. Additionally, a significance level of $p < .05$ was set for hypothesis testing, with p-values less than .05 considered statistically significant.

3. Results

Table 1 presents the means and standard deviations of pre-test and post-test values, including body mass index (BMI), gross motor skills, fine motor skills, and upper limb coordination for the aerobic, resistance training, and control groups.

Table 1. Descriptive Variables in Research Groups

Variable	Group	Pre-test Mean ± SD	Post-test Mean ± SD	Significance Test (p-value)
Body Mass Index (BMI)	Aerobic	18.42 ± 2.78	17.87 ± 2.42	0.870
	Resistance	19.46 ± 5.18	19.20 ± 4.93	
	Control	18.19 ± 2.98	18.82 ± 2.78	
Gross Motor Skills	Aerobic	5.50 ± 5.40	11.40 ± 5.60	0.007
	Resistance	7.30 ± 4.27	11.80 ± 3.58	
	Control	8.00 ± 4.39	6.60 ± 3.71	
Fine Motor Skills	Aerobic	4.20 ± 3.58	11.40 ± 7.45	0.021
	Resistance	4.50 ± 3.27	12.60 ± 4.97	
	Control	6.90 ± 7.43	5.70 ± 5.45	
Upper Limb Coordination	Aerobic	1.00 ± 1.94	2.30 ± 1.70	0.050
	Resistance	1.30 ± 1.56	3.30 ± 1.25	
	Control	1.30 ± 1.25	1.00 ± 0.94	

Analysis of the interaction effect between group and time, based on $p = .870 > .05$, indicates that there was no significant difference between the two exercise programs (aerobic and resistance) in terms of BMI. Based on $p = .021 < .05$, a significant difference was observed among the control, aerobic, and resistance groups regarding fine motor skills. According to $p = .007 < .05$, there was a significant difference among the control, aerobic, and resistance groups in terms of gross motor skills. Furthermore, based on $p = .050 > .05$, no significant difference was found among the control, aerobic, and resistance groups concerning upper limb coordination in boys with Down syndrome in Tehran.

The changes in BMI for boys with Down syndrome in Tehran across the aerobic, resistance, and control groups at the pre-test and post-test stages are illustrated in Figure 1.

The changes in fine motor skills for boys with Down syndrome in Tehran across different research groups at the pre-test and post-test stages are shown in Figure 2.

The changes in gross motor skills for boys with Down syndrome in Tehran across different research groups at the pre-test and post-test stages are presented in Figure 3.

The changes in upper limb coordination for boys with Down syndrome in Tehran across different research groups at the pre-test and post-test stages are displayed in Figure 4.

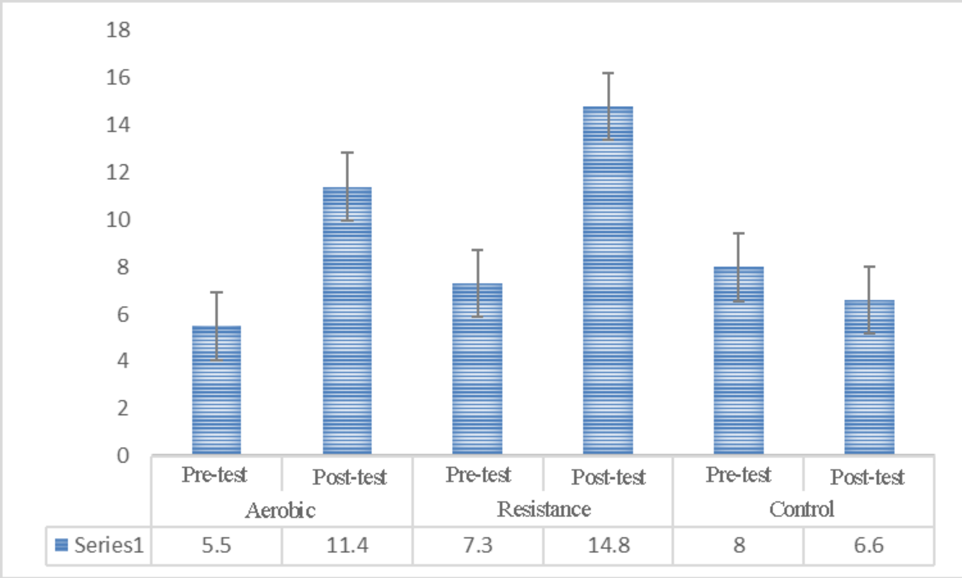

Figure 1. Changes in BMI for Boys with Down Syndrome in Tehran Across Research Groups

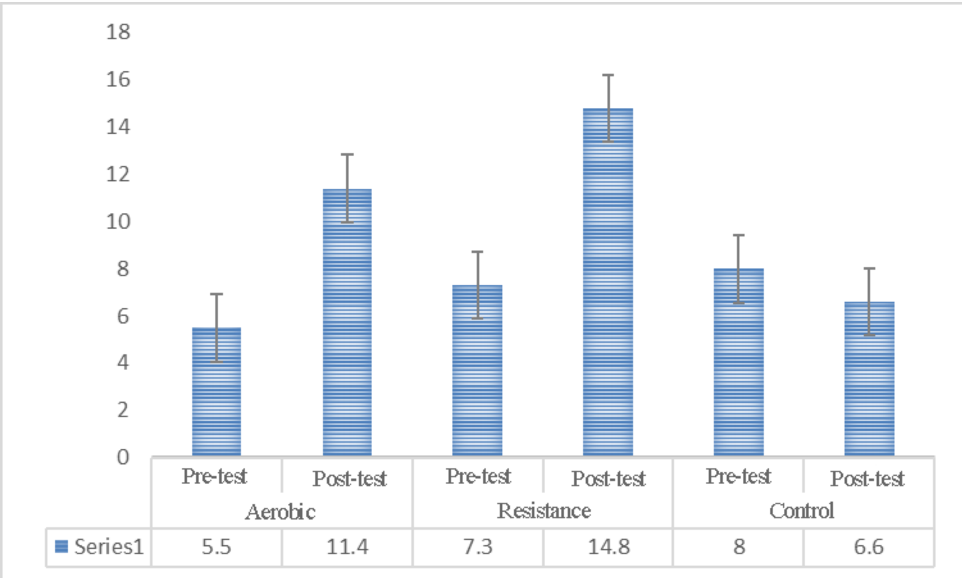

Figure 2. Changes in Fine Motor Skills for Boys with Down Syndrome in Tehran Across Research Groups

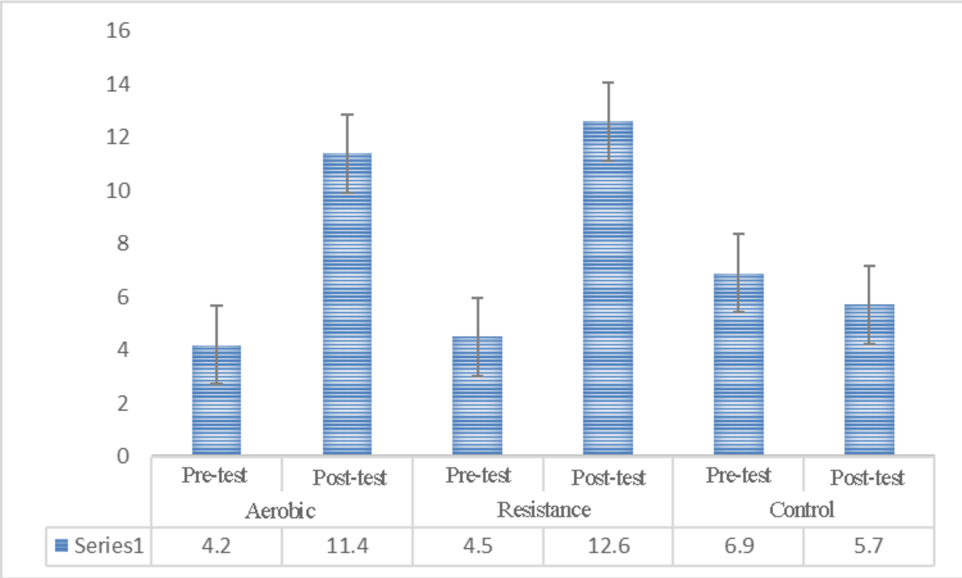

Figure 3. Changes in Gross Motor Skills for Boys with Down Syndrome in Tehran Across Research Groups

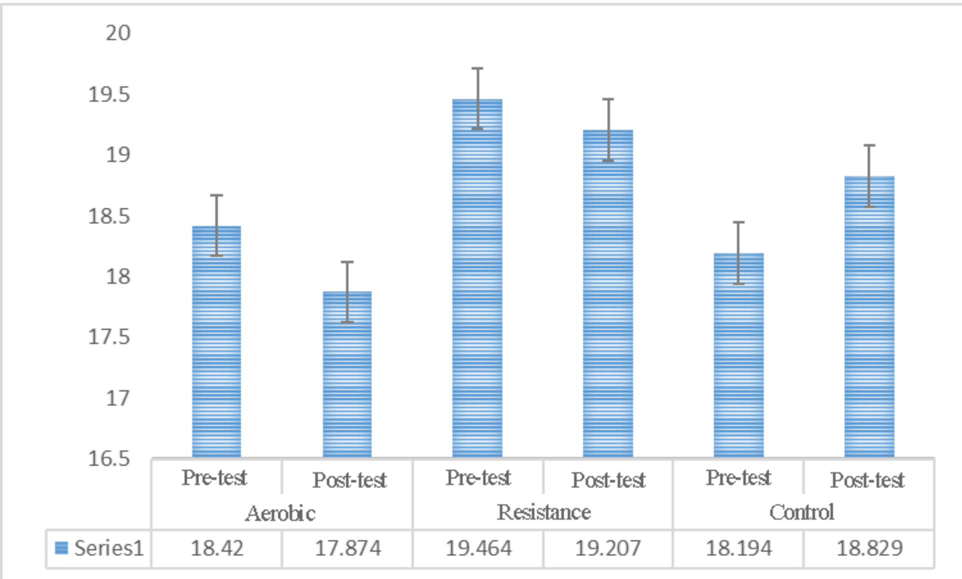

Figure 4. Changes in Upper Limb Coordination for Boys with Down Syndrome in Tehran Across Research Groups

4. Discussion and Conclusion

In the present study, there was no significant difference in the mean BMI of boys with Down syndrome in Tehran between the pre-test and post-test across the control, aerobic, and resistance training groups. Although both exercise types affected BMI, the results indicate that aerobic and resistance training programs similarly altered BMI in boys with Down syndrome. Following both types of exercise, there was a significant increase in BMI, but the increase was somewhat consistent across both training types. Ordonez et al. (2006) conducted a study in which they engaged 22 overweight and obese adolescents with Down syndrome in exercise programs (both aquatic and land-based) for three months, three sessions per week, and observed a significant reduction in body fat. It is possible that the specific characteristics of these aquatic and land-based exercises contributed to this reduction (19). Similarly, findings from research show that body composition (weight, BMI, total skinfold thickness, and waist circumference) in elementary school boys with Down syndrome significantly improved after six weeks of aerobic and resistance training (20). In contrast, González-

Agüero et al. (2010) found no reduction in body fat percentage or BMI after 21 weeks of combined strength training, conducted twice weekly, in individuals with Down syndrome (6). Rimmer et al. (2004) also reported that after a 12-week intervention using a combined aerobic and resistance exercise program, conducted three times per week with 52 adults with Down syndrome, body weight decreased, although there was no change in BMI (21).

In this study, aerobic and resistance training influenced the fine motor skills of boys with Down syndrome. This indicates that aerobic and resistance training programs do not equally impact fine motor skills in boys with Down syndrome but have different effects, with resistance training having a greater effect compared to aerobic training. Thus, while both types of training positively affect fine motor skills, resistance training had a more pronounced impact. In line with this, Wuang et al. (2009) examined the effect of sensory integration, perceptual-motor, and neurodevelopmental exercises on the sensory and motor skills of children with intellectual disabilities. They noted that the group performing sensory-motor skills exercises showed better fine motor skills, while the perceptual-motor group exhibited higher gross motor skills. They suggested that each training method enhances specific aspects of motor skills in these children (22). Therefore, the findings of Wuang et al.'s study align with the results of the present study.

In this research, there was a significant difference between the effects of aerobic and resistance training programs on the gross motor skills of boys with Down syndrome in Tehran. This suggests that aerobic and resistance training programs are not equally effective for improving gross motor skills in boys with Down syndrome, and the effects of these two types of training differ. Both types of exercise improved gross motor skills, but resistance training led to a greater increase in gross motor skills compared to aerobic training. Ahmadi et al. (2021) conducted a study titled "The Effectiveness of Group Aerobic Exercises Based on Sensory Integration Theory on Gross and Fine Motor Skills in Children with Down Syndrome" and found significant differences in gross motor skills between the two groups (23).

Additionally, there was a significant difference in the impact of aerobic and resistance training programs on upper limb coordination in boys with Down syndrome in Tehran. This indicates that aerobic and resistance training programs are not equally effective for upper limb coordination in boys with Down syndrome. Further analysis revealed that resistance training had a greater effect on upper limb coordination compared to aerobic training, with aerobic training being less effective. Regarding upper limb coordination, Ahmadi et al. (2021) demonstrated significant differences between two groups in their study titled "The Effectiveness of Group Aerobic Exercises Based on Sensory Integration Theory on Gross and Fine Motor Skills in Children with Down Syndrome" (23). Thus, the results of Ahmadi et al.'s study are consistent with the findings of the present research.

This study shows that aerobic and resistance training can be effective methods for improving BMI and perceptual-motor performance in boys with Down syndrome. The findings not only confirm the importance of this therapeutic approach but also suggest the potential for developing comprehensive intervention programs aimed at enhancing the quality of life for individuals with Down syndrome.

Overall, a combined training program to improve all four variables (BMI, fine motor skills, gross motor skills, and upper limb coordination) could begin with aerobic exercises for warming up and increasing blood flow, followed by resistance training. In aerobic exercises, a different exercise should be used for each session, such as long-duration walking in one session, track and field exercises in another, and swimming in a subsequent session. After each aerobic exercise, strength training targeting different body parts in each session should be conducted.

Authors' Contributions

F. T. and R. K. contributed to the conception and design of the study. F. T. was responsible for the development and implementation of the exercise intervention protocols and conducted the data collection sessions. R. K. managed the statistical analysis and interpretation of the data. Both authors collaborated on drafting the manuscript and revising it critically for important intellectual content. They approved the final version of the manuscript for publication and agreed to be accountable for all aspects of the research.

Declaration

In order to correct and improve the academic writing of our paper, we have used the language model ChatGPT.

Transparency Statement

Data are available for research purposes upon reasonable request to the corresponding author.

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Declaration of Interest

The authors report no conflict of interest.

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Ethics Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants. The ethical approval code for this study is IR.PNU.REC.1402.238.

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