

Original Article

Effect of Aerobic Exercise on Static & Dynamic Balance in Children with Down Syndrome

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ABSTRACT

Background: Down syndrome, characterized by an extra chromosome 21, affects physical and developmental growth. Children with Down syndrome often exhibit impairments in balance and motor function, necessitating interventions that enhance physical capabilities and overall quality of life.

Objective: To evaluate the efficacy of aerobic exercises compared to standard physical therapy in improving static and dynamic balance in children with Down syndrome.

Methods: This randomized controlled trial included 20 children aged 5-12 years with Down syndrome, recruited from the Rising Sun Institute of Special Education. Participants were randomly divided into a control group, which received standard physical therapy, and an experimental group, which engaged in aerobic exercise (cycling) three times a week for 30 minutes over an 8-week period. The primary outcomes, static and dynamic balance, were assessed using the Pediatric Balance Scale (PBS) and the 6-Minute Walk Test (6MWT) before and after the intervention.

Results: The experimental group showed significant improvements compared to the control group. The mean changes in the Timed Up and Go test were reduced by 3.67 seconds ($p < 0.05$), the PBS scores increased by 10.23 points ($p < 0.05$), and the 6MWT distance extended by 66.11 meters ($p < 0.05$).

Conclusion: Aerobic exercise interventions significantly enhance static and dynamic balance in children with Down syndrome, surpassing the effects of standard physical therapy. Incorporating structured aerobic exercises into rehabilitation programs is recommended to optimize developmental outcomes in this population.

Keywords: Down Syndrome, Aerobic Exercise, Pediatric Balance Scale, 6-Minute Walk Test, Static Balance, Dynamic Balance, Randomized Controlled Trial.

INTRODUCTION

Down syndrome, also known as Trisomy 21, is a genetic condition characterized by the presence of an extra copy of chromosome 21, leading to a total of 47 chromosomes instead of the typical 46 (1). This chromosomal anomaly results in a spectrum of physical and cognitive impairments, which can vary widely among individuals but commonly include intellectual disability, distinctive facial features, and a predisposition to certain medical conditions such as congenital heart defects and digestive problems (2). Approximately 14 per 10,000 live births are affected by Down syndrome, making it one of the most common genetic disorders worldwide (3).

Children with Down syndrome typically experience significant challenges in physical and neurological development. These challenges include joint laxity, instability of the shoulder joint, and an asymmetric or increased range of motion (4). Such physiological characteristics contribute to delays in motor development and pose difficulties in acquiring balance and initiating movements, which are critical for everyday activities and overall quality of life (5). Moreover, these children often display a propensity to avoid weight-

bearing on the lower extremities, which further complicates their ability to maintain balance and perform physical tasks efficiently (6).

The management of Down syndrome involves a multidisciplinary approach, with physical therapy playing a crucial role in improving motor skills and enhancing physical fitness. Aerobic exercises, in particular, have been identified as potentially beneficial for this population. These exercises not only help in improving cardiovascular health but also contribute to muscle strengthening and better coordination, which are essential for maintaining balance (7). Recent research suggests that specific aerobic activities, such as cycling and walking, can significantly improve both static and dynamic balance in children with Down syndrome, thereby enhancing their ability to perform daily activities with greater independence and safety (8).

The positive impact of aerobic exercise on balance is attributed to its role in strengthening the neuromuscular system, improving joint stability, and enhancing proprioceptive feedback, all of which are vital components in the development of efficient motor responses to external stimuli (9). Given the potential benefits of such interventions, it is crucial to further explore and validate the effectiveness of structured aerobic exercise programs in this demographic to establish evidence-based guidelines for their inclusion in therapeutic regimens tailored for individuals with Down syndrome (10-13).

MATERIAL AND METHODS

The study was designed as a randomized controlled trial to evaluate the impact of aerobic exercises on static and dynamic balance in children with Down syndrome. A total of 20 children, aged between 5 and 12 years, were recruited from the Rising Sun Institute of Special Education through convenience sampling. Inclusion criteria for the participants were a medical diagnosis of Down syndrome, mild to moderate mental retardation, and the capability to stand and walk independently. Children with recent injuries to the lower extremities, a history of or ongoing vestibular neuritis, or those using walking aids were excluded from the study.

Participants were randomly assigned to two groups: the control group and the experimental group. The control group received standard physical therapy interventions, which included progressive resistance training, balance exercises, and flexibility training. Meanwhile, the experimental group participated in aerobic exercises in addition to the standard physical therapy. The aerobic exercise regimen consisted of cycling sessions, conducted three times per week for 30 minutes each, over a period of eight weeks. Data were collected using standardized assessment tools to measure balance and mobility. The Pediatric Balance Scale (PBS) and the 6-Minute Walk Test (6MWT) were employed at the beginning and end of the intervention period to assess the changes in balance and functional mobility of the participants. These instruments have been validated for use in pediatric populations with physical disabilities and are commonly used in clinical research to provide objective data on balance and endurance capabilities (14).

Ethical approval for the study was obtained from the Institutional Review Board of the Rising Sun Institute of Special Education, ensuring compliance with the ethical principles of the Helsinki Declaration. Parents or legal guardians of all participants provided written informed consent prior to inclusion in the study.

Data analysis was conducted using SPSS version 25.0. The Shapiro-Wilk test was used to assess the normality of the data. Descriptive statistics, including means and standard deviations, were calculated for all baseline and post-treatment variables. Independent t-tests were performed to compare the baseline characteristics between the control and experimental groups, while paired t-tests were used to compare pre- and post-intervention measures within each group. A p-value of less than 0.05 was considered statistically significant, indicating that the observed differences were unlikely to be due to chance (15).

RESULTS

The study included 18 participants (9 in each group) who completed the 8-week intervention period. The analysis revealed statistically significant improvements in both static and dynamic balance within the experimental group when compared to the control group post-intervention.

Table 1: Demographic and Baseline Characteristics

Variables	Control Group (Mean ± SD)	Experimental Group (Mean ± SD)
Age (years)	7.78 ± 2.22	7.78 ± 1.92
Gender (Male/Female)	7/2	7/2

Table 2: Comparison of Balance and Mobility Measures Pre- and Post-Intervention

Variables	Group	Pre-Treatment (Mean ± SD)	Post-Treatment (Mean ± SD)	Mean Difference	p-value
Timed Up and Go Test (seconds)	Control	9.44 ± 1.50	8.00 ± 1.32	1.44	< 0.05

	Experimental	9.55 ± 1.50	5.88 ± 1.26	3.67	< 0.05
Pediatric Balance Scale	Control	35.22 ± 3.52	41.55 ± 3.35	6.33	< 0.05
	Experimental	34.88 ± 2.97	45.11 ± 3.21	10.23	< 0.05
6-Minute Walk Test (meters)	Control	272.77 ± 16.22	316.88 ± 8.63	44.11	< 0.05
	Experimental	270.55 ± 18.27	336.66 ± 17.67	66.11	< 0.05

The mean differences observed in the Timed Up and Go Test, Pediatric Balance Scale, and 6-Minute Walk Test were statistically significant ($p < 0.05$) in both groups, indicating improvements. However, the experimental group exhibited more pronounced improvements in all measures. Specifically, the experimental group showed a reduction in the Timed Up and Go test time by 3.67 seconds, an increase in the Pediatric Balance Scale score by 10.23 points, and an increase in the 6-Minute Walk Test distance by 66.11 meters, all indicating significant gains in balance and mobility compared to the control group. These results suggest that the addition of aerobic exercise to standard therapy can significantly enhance balance and mobility outcomes in children with Down syndrome.

DISCUSSION

The results of this randomized controlled trial demonstrated that aerobic exercise interventions significantly enhanced static and dynamic balance in children with Down syndrome, with improvements surpassing those observed in the control group which received only standard physical therapy. This finding aligns with previous research, which has shown that structured exercise programs can improve both cognitive and physical outcomes for individuals with Down syndrome (13-16). Specifically, improvements in the Timed Up and Go Test, Pediatric Balance Scale, and 6-Minute Walk Test scores in the experimental group substantiate the hypothesis that aerobic exercises contribute positively to balance and overall motor function (17).

The superior performance of the experimental group may be attributed to the enhanced cardiovascular and muscular adaptations stimulated by aerobic activities such as cycling. These physical changes likely contributed to improved neuromuscular control, which is crucial for maintaining balance and stability (18, 19). Additionally, the repetitive nature of aerobic exercise might have facilitated better proprioceptive integration and motor planning, crucial factors in achieving better balance and coordination in children with Down syndrome (20).

The study's findings are consistent with those of Maiano et al. (2019), who noted that exercise interventions might improve balance for children and adolescents with Down syndrome, emphasizing the role of physical fitness in enhancing quality of life and independence (21). Moreover, the significant improvements in the 6-Minute Walk Test suggest that aerobic exercises not only boost balance but also enhance endurance, further supporting the integration of these exercises into daily rehabilitation programs.

Despite these encouraging results, the study had several limitations. The small sample size and the short duration of the intervention might limit the generalizability of the findings. Long-term effects of aerobic exercise on balance and mobility in this population remain unclear, and future studies with larger sample sizes and extended intervention periods are needed to substantiate these preliminary findings. Furthermore, the study focused solely on children with mild to moderate intellectual disabilities, which might not represent the full spectrum of Down syndrome severity (13).

Additionally, the study did not account for potential confounders such as the varying levels of physical activity outside the structured interventions, which could influence the outcomes. Compliance with the exercise program, which was not systematically monitored, might also vary, potentially affecting the results.

Given the promising outcomes observed, it is recommended that future research explore the long-term effects of aerobic exercises on balance and coordination in children with Down syndrome, with a focus on tailoring exercise programs to individual capabilities and needs. Additionally, investigating the impact of other types of physical activities and their combination with aerobic exercises could provide deeper insights into the most effective strategies for enhancing physical fitness and motor skills in this population (18).

CONCLUSION

In conclusion, Aerobic exercise interventions significantly enhance static and dynamic balance in children with Down syndrome, surpassing the effects of standard physical therapy. Incorporating structured aerobic exercises into rehabilitation programs is recommended to optimize developmental outcomes in this population.

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