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The Effect of a Suggested Exercise Program on Balance and Cardiovascular Fitness in Children with Down Syndrome: A Quasi Comparative Study

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Thesis Approval

The Effect of a Suggested Exercise Program on Balance and Cardiovascular Fitness in Children with Down Syndrome: A Quasi Comparative Study

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Dedication

Above all, I dedicate this work to God, for granting me strength, wisdom, and perseverance to reach this milestone. Every success is by His Grace.

To the soul of my beloved father, whose memory continues to inspire and guide me every day. Your spirit has been my strength, and your values continue to shape my path. May your soul rest in Peace.

To my dear mother, whose endless love, prayers, and sacrifices have been the foundation of all my accomplishments? Your patience, encouragement, and faith in me have given me the courage to pursue my dreams and overcome every challenge. You are my greatest blessing.

Special thanks to my supervisor, Dr. Hadeel Halaweh, for her guidance, knowledge, and encouragement, which greatly enriched my research and personal growth.

Declaration

I certify that this thesis, submitted for the degree of Master's, is the result of my own research, except where otherwise acknowledged, and that this thesis (or any part of the same material) has not been submitted for a higher degree to any other university or institution.

Signed: Razan Hilal

Razan Michael Hilal

Date: 24/11/2025

Acknowledgement

First of all, I thank GOD “Allah”, gratitude from the beginning and the end that he enabled me to complete this success and realize my dream, after two years of toil for the sake of dreams and knowledge, which carried within them long-held hopes. Today, my effort has become a joy to behold, and here I stand on the threshold of graduation, raising my hat with pride. You have enabled me to complete this success and realize my dream.

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To the hands that never held back in giving or hesitated to offer assistance, even for a moment. My esteemed professors and the discussion committee.

Researcher: Razan Michael Hilal

The Effect of a Suggested Exercise Program on Balance and Cardiovascular Fitness in Children with Down Syndrome: A Quasi-Comparative Study

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Abstract

Background: Down syndrome (DS), or trisomy 21, is a genetic disorder caused by having an extra copy of chromosome 21, which leads to physical and intellectual disabilities, typical facial features, delayed growth, and hypotonia. DS's people objected to medical complications: heart defects, obesity, and diabetes.

Objective: To evaluate the effectiveness of a structured exercise program that integrates aerobic exercise and balance training, toward improving cardiovascular fitness and balance among DS's children.

Methods: A quasi-comparative (single-blinded) study conducted with 40 DS's children aged 4 to 12 years from Jemima and Life Gate in Beit Jala. Participants were assigned by convenience sampling to either experimental group, which engaged in a structured exercise program for two sessions per week, with a 60-minute duration, over 12 weeks. Or to control group received standard physiotherapy sessions. Balance and cardiovascular fitness were assessed using the pre- and post-Berg Balance (PBB) Test and the 6-minute walk (6MWT) test.

Results: The findings indicate that the structured exercise program had significant improvements in cardiovascular endurance and balance among DS's children. Participants in the intervention group demonstrated a statistically significant increase in 6MW Test ($p=0.001$) with a very large effect size (Cohen's $d=3.433$), alongside marked improvements in overall balance as measured by the PBB Scale ($p=0.001$, Cohen's $d=1.447$) compared to the control group. Notably, the intervention group showed substantial gains in specific balance tasks, including more challenging activities such as turning 360 degrees and standing on one foot ($p=0.001$). Furthermore, a strong positive correlation was found between cardiovascular endurance and balance at post-test ($r=0.663$, $p=0.001$).

Conclusion: This study demonstrates that a structured exercise program combining aerobic and balance training can effectively enhance cardiovascular endurance and balance among DS's children. Suggesting that targeted physical activity interventions may play a crucial role in promoting overall motor function and physical fitness among DS.

Keywords: Down syndrome, structured exercise program, cardiovascular fitness, balance training.

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List of Abbreviation

Abbreviation	Meaning
DS	Down Syndrome
CRF	Cardiorespiratory Fitness
NDT	Neurodevelopmental Treatment.
SIT	Sensory Integration Therapy
IDEA	Intellectual disability Exercise Aging

Chapter One

Background

1.1 Introduction.

Down syndrome (DS), or trisomy 21, is a genetic condition. An extra copy of chromosome 21 causes it. It leads to physical and intellectual disabilities (Muñoz-Llerena et al. 2024a). It is one of the most common genetic disorders. It occurs in about 1 in 700 to 1,000 live births worldwide (Moretti et al. 2025). A study in Palestine found that 5% of pregnant women were at high risk for having a fetus with Down syndrome, based on serum screening (Akkawi et al. 2011). Individuals with Down syndrome have distinctive facial features, including a flat facial profile, upward-slanting eyes, and a single transverse palmar crease. They often experience growth retardation and hypotonia, characterized by decreased muscle tone (Antonarakis et al. 2020) . Moreover, those with Down syndrome face a higher risk of gastrointestinal problems, blood disorders, neurologic issues (like seizures and dementia), endocrine disorders (like hypothyroidism), and musculoskeletal disorders (Antonarakis et al. 2020).

The incidence of Down syndrome (DS) has risen. Those with DS often have heart defects, low fitness, and high rates of obesity and type 2 diabetes. (Gupta 2024a). Regular physical activity is crucial for these individuals. It helps reduce health risks by boosting cardiovascular fitness, muscle strength, and well-being. This, in turn, prevents chronic diseases linked to inactivity (Bahiraei et al. 2023a). A systematic review by (Maïano et al. 2019) revealed that exercise interventions can greatly enhance balance in children and adolescents with Down syndrome, improving both static and dynamic balance.

Beyond physical improvements, exercise can also provide psychological and social benefits for individuals with Down syndrome. Structured exercise programs may improve cognitive functions such as attention and everyday executive skills (Duan and Li 2025). When activities are delivered in an enjoyable, game-like format and include support from therapists or peers, they can increase motivation, social interaction, and mood (Merzbach et al. 2024a). These combined physical and psychosocial effects may help children feel more competent and engaged in their daily activities (Méndez-Martínez and Rodríguez-Grande 2023)

1.2 Problem Statement

Many individuals with Down syndrome have low fitness, balance, and cardiovascular health. This is despite the well-documented benefits of regular exercise. Such deficiencies raise health risks, reduce mobility, and lower life quality (Gupta 2024b). Research shows that poor balance is common in this population. It greatly increases the risk of falls and injuries (Jain et al. 2022). They should improve cardiovascular fitness and balance (Hendrix et al. 2021) Neglecting to enhance these traits may raise obesity rates (Melo et al. 2022). This could harm health, reduce independence, and lower well-being and longevity. There is little research in Palestine on Down Syndrome and specifically research on exercise programs for people with Down syndrome. Therefore, this study aims to assess the effectiveness of a structured exercise program combining aerobic exercise and balance training on balance and cardiovascular health in children with DS.

1.3 Study Justification (Rationale)

Down syndrome (DS) presents unique challenges that limit physical activity and fitness. These challenges include low muscle tone, weak muscles, and a higher risk of obesity. This increases the risk of health issues, like heart disease and diabetes (Melo et al. 2022). Children with DS often have delays in cognition, speech, and communication. These can hinder their motivation and understanding of exercise routines. So, they may struggle to join traditional fitness programs (Alghamdi et al. 2021). Research shows many children with DS are inactive, leading to lower quality of life and raising obesity risk (Ulrich et al. 2011). The World Health Organization recommends that children should do 60 minutes of moderate to vigorous activity daily. However, it's hard for kids with disabilities, especially those with Down syndrome, to meet this goal. Consequently, they are at a higher risk for inactivity (Alghamdi et al. 2021).

There is a significant need for more exercise among people with DS. Yet, there are few exercise programs made for their unique needs. Current fitness initiatives often overlook the need to adapt activities. They should fit users' physical and mental abilities. Previous studies found barriers to participation. These include a lack of suitable programs, family obligations, and stigma around disabilities (Barr and Shields 2011). Also, traits linked to DS, like hypotonia and poor balance, hinder their physical activity (Sanyer 2006)). This gap in research highlights the need for studies. To explore approaches to promote physical activity in this population. By identifying their barriers and motivators, we can create better fitness programs which may help children with DS to be more inclusive and effective.

This research could improve the health of people with Down syndrome. It aims to create fun, easy-to-use exercise programs to meet their unique challenges. Tailored fitness programs provide vital benefits; they can reduce the risks of obesity, heart disease, and other health issues. Regular exercise improves muscle strength, balance, and function (Montalva-Valenzuela et al. 2024a).

1.4 Research Hypotheses

1. Children with Down syndrome who participate in a structured exercise program that combines aerobic exercise and balance training will show significant improvements in cardiovascular fitness compared to those who do not participate in the program.
2. Children in the structured exercise program will demonstrate improved balance compared to a control group.

1.5 Research Objectives

1. To evaluate the effectiveness of a structured exercise program that integrates aerobic exercise and balance training on improving cardiovascular fitness in children with Down syndrome.
2. To assess changes in balance among children in the exercise program compared to a control group.

1.6 Research Questions

1. What are the effects of a structured exercise program on cardiovascular fitness levels in children with Down syndrome?
2. How does participation in the exercise program influence balance among children with Down syndrome?

1.7 Terminology

Hypotonia is a condition. It reduces muscle tone. This decreases resistance to passive movement. It makes infants appear "floppy." It can harm their motor skills and function. It is often linked to neurological conditions. This can hinder the assessment and management of those affected. (Hidalgo Robles, Paleg, and Livingstone 2024)

Static balance is the ability to stay still on a stable, fixed base. It involves controlling the center of gravity over the base of support while remaining still. This balance is crucial for tasks that require stillness. These include standing or maintaining an upright posture (Gonçalves et al. 2021)

Dynamic Balance: It is the ability to stay stable while moving or changing positions. It involves moving one's center of gravity over the base. Then, it requires maintaining balance after changes in position (Gonçalves et al. 2021). Dynamic balance is key for moving activities. These include walking, running, and changing direction.

Chapter Two

Literature Review

2. 1. Theoretical Studies

2.1.1 Definition of Down syndrome

Down syndrome was initially identified by the English physician John Langdon Down in 1866. However, it wasn't until almost a hundred years later that Dr. Jerome Lejeune in Paris linked the condition to chromosome 21. This genetic disorder occurs due to an extra copy of chromosome 21, making it the most prevalent chromosomal abnormality in humans (Akhtar and Bokhari 2024).

The prevalence varies across different populations (ranging from 1 in 319 to 1 in 1000 live births). It's also noted that while the frequency of Down syndrome fetuses is relatively high at conception, approximately 50% to 75% of these pregnancies end in loss before reaching term (Akhtar and Bokhari 2024).

Down syndrome (DS) is mainly caused by an extra copy of chromosome 21, and several risk factors can increase the chances of having a child with this condition. One of the most important risk factors is advanced maternal age, especially after 35 years, as the likelihood of chromosomal errors during egg formation rises with age. Moreover, couples who have had a child with Down syndrome previously are at a greater risk of having another affected child, particularly if the earlier case involved translocation Down syndrome. Parental genetic translocations also contribute; if a parent has a chromosomal translocation, the chances of having a child with Down syndrome increase. Certain genetic variations, like mosaic Down syndrome and Robertsonian translocations, add to this risk. While the main causes are genetic, some environmental factors, such as maternal exposure to chemicals or toxins during pregnancy, might also affect the likelihood of Down syndrome, although the evidence supporting these connections is still limited and inconclusive. Recognizing these risk factors is crucial for early detection and management of Down syndrome, allowing families to make informed choices about prenatal testing and genetic counseling.(Smith 2023)

2.1.2 Cardiorespiratory fitness and Down syndrome:

Cardiorespiratory fitness (CRF) is the ability to deliver oxygen to muscle mitochondria for energy during exercise. It relies on the circulatory and respiratory systems. It is a key indicator of physical and mental health. Low CRF levels strongly raise the risk of heart disease and death. Also, CRF predicts health outcomes in children and adolescents. This includes cardiometabolic health and mental well-being. (Raghuveer et al. 2020)

Individuals with Down syndrome (DS) often experience low levels of cardiorespiratory fitness, and previous research has indicated that these low fitness levels have a physiological basis.(Beck et al. 2022)

2.1.3 Balance:

Balance is defined as adapting to movements and challenges. It is keeping a stable center of gravity. This capacity is task-specific, involving various components, such as static and dynamic balance. *(Cui et al. 2024)*

Static Balance:

Static balance is the ability to stay stable while standing still or in a fixed position. It means holding a position without moving, relying on muscle strength and proprioception to stay stable. *Cui et al. 2024)*

In static balance, the CoG must stay within the boundaries of the BoS to keep equilibrium; if it moves outside this area, balance is compromised (Schedler et al. 2024)

Dynamic Balance:

Dynamic balance is the ability to stay stable while moving or changing positions. It requires coordination and control during activities such as walking, running, or jumping. (Cui et al. 2024)

• In dynamic balance, ongoing adjustments are required to ensure the CoG remains within the BoS during activities such as walking or running (Schedler et al. 2024)

Balance plays a crucial role in ensuring the safety and independence of children with Down syndrome (DS), as it is essential for walking and motor coordination. Difficulties with balance can impede the development of body awareness and overall motor skills, which are vital for performing daily tasks. Various physical traits associated with DS contribute to these balance challenges, such as muscle hypotonia, ligament laxity, flat feet, cerebellar hypoplasia, and issues with vision and hearing. These factors can create obstacles in keeping the center of gravity stable within the base of support during physical activities. Consequently, interventions for children with DS should prioritize the enhancement of various motor skills in conjunction with balance training. Well-structured physical exercise programs that include balance training are key to improving overall motor function. (Lourenço, Melo, and Boato 2021)

2.1.4 Role of Physiotherapy in Down Syndrome

Clinical guidelines for physiotherapy in people with Down syndrome stress early intervention. They also call for treatment plans tailored to each child's unique needs. A physiotherapist's detailed initial assessment is vital; it must identify issues such as hypotonia, muscle weakness, and joint laxity. This will help create a personalized therapy plan. Effective physiotherapy uses diverse techniques, including neurodevelopmental treatment (NDT), sensory integration therapy (SIT), strengthening exercises, balance training, and cardiorespiratory fitness. And they support achieving milestones like sitting, crawling, standing, and walking.

Additionally, family education is vital; therapists guide parents on techniques to promote their child's independence, and continuous progress monitoring allows for treatment plan adjustments. This ensures interventions stay effective. A multidisciplinary approach is fundamental with DS. it must include collaboration with occupational and speech therapists, which is essential to meet the comprehensive needs of children with Down syndrome and enhance their physical function and quality of life(Suleyman, 2020)

Exercise physiology helps us understand how exercise affects the body. This is especially true for people with unique needs, like those with Down syndrome (DS). Regular exercise boosts heart health, strength, and fitness (Montalva-Valenzuela et al. 2024b), indicating that tailored exercise programs can greatly improve fitness and body composition in those with DS. This highlights the importance of specific exercise prescriptions to achieve desired health outcomes.

2.2. Similar Studies

Research shows that exercise is vital for improving cardiovascular health and overall fitness in individuals with Down syndrome (DS) and other intellectual disabilities. A systematic review by (Bahiraei et al. 2023b) indicates that structured aerobic exercise leads to significant enhancements in cardiovascular responses, such as increased peak oxygen uptake (VO_2peak) and longer time to exhaustion. This is further supported by findings from the Rowan-Virtua, which revealed that moderate to vigorous treadmill exercise significantly elevates heart rates and oxygen utilization in adolescents with DS, thus improving cardiovascular fitness (Gupta 2024b).

In addition, targeted physical therapy has been proven to enhance balance and strength, which are crucial for overall functional improvement in individuals with DS (Ahmad et al. 2023) Resistance training has also been shown to lower cardiovascular risks in adults with intellectual disabilities, as noted by (Weterings, Oppewal, and Hilgenkamp 2020).

Evidence suggests that neuromuscular exercises positively impact strength and balance in children with DS (Rodríguez-Grande et al. 2022). The IDEA study further supports these findings, demonstrating that both aerobic and sprint interval training improve cardiovascular health in individuals with intellectual disabilities (Oviedo et al. 2020)

Moreover, (Vandoni et al. 2023) found that targeted interventions can boost motor skills and executive functions in children with DS. Longitudinal studies highlight the significance of structured exercise programs for adults with DS, emphasizing the need for ongoing physical activity to sustain health benefits.

Research indicates that exercise significantly enhances cardiovascular health, balance, and overall function in individuals with Down syndrome (DS). Numerous studies, including systematic reviews by (Ruiz-González et al. 2019) demonstrate that aerobic exercise can substantially boost heart health by increasing peak oxygen uptake (VO_2peak) and endurance. Additionally, targeted physical therapy has been shown to improve balance and strength, which are essential for enhancing functionality in people with DS (Melo et al. 2022).

Resistance training is also beneficial, as it can reduce the risk of heart disease in adults with intellectual disabilities (Elbers et al. 2022). Furthermore, neuromuscular exercises have been found to enhance strength and balance in children with Down syndrome (Rodríguez-Grande et al. 2022)

However, some studies present differing opinions on the recommended intensity of exercise for individuals with DS. For example, (Canpolat 2023) suggests that while low-intensity exercises can positively impact cardiovascular health, high-intensity workouts may carry risks due to the cardiovascular vulnerabilities often associated with DS. This underscores the importance of caution when developing exercise programs for this group.

Despite these encouraging findings, there are still gaps in the existing literature. Many studies tend to concentrate on short-term outcomes or specific types of exercises, overlooking integrated approaches that combine various forms of exercise tailored for individuals with DS. Research on combined exercise programs that incorporate balance training is limited. While both aerobic and resistance training offer benefits, their long-term effects remain uncertain. Additionally, more research is needed in Palestine to explore how different physical activities can be utilized within communities to enhance adherence among individuals with DS.

Chapter Three

Methodology

3.1 Introduction

The methodology of the study is presented in this chapter. The research design, study population and settings, validity and reliability, data collection methods, data entry, and analysis techniques are all covered in detail in this chapter.

3.2. Study Design

This study employed a quasi-comparative design to assess the effectiveness of a structured exercise program on cardiovascular fitness and balance among children with Down syndrome. This design was deemed appropriate as it enables the comparison of outcomes measured before and after the intervention.

3.3. Study Setting

The study was conducted at the Jemima Foundation, an institution dedicated to supporting children with intellectual disabilities. This setting was selected due to its emphasis on promoting physical activity and its availability of appropriate exercise facilities, including an indoor hall and outdoor recreational areas.

3.4. Study Sample

3.4.1 Sampling Method

A convenience sampling was used to select participants from the Jemima Foundation and Life Gate Rehabilitation; both institutions served children with Down syndrome. This method was chosen in this study for its practicality. It suited the population and their accessibility needs.

3.4.2 Study Sample

A total of 40 participants was recruited, with 20 assigned to the intervention-structured exercise program and 20 to a control group.

3.4.3 Inclusion Criteria

- Aged between 4 to 12 years.
- Confirmed diagnosis of Down syndrome.
- No major orthopedic or cardiovascular conditions that would contraindicate participation in an exercise program.
- Children were recruited with the consent of their families or the directors (guardians) of the institutions they attended.

3.4.4 Exclusion Criteria

Potential participants were excluded if they:

- Had significant medical conditions that affected mobility (e.g., severe heart defects).
- Were currently participating in another structured exercise program.
- Had any acute illness or injury at the time of recruitment.
- Children were excluded if they did not have consent from their families or the directors of the institutions they attended.

3.5. Data Collection

3.5.1 Tools of Data Collection

Data were collected using the following instruments:

- **The Pediatric Balance Scale (PBS)** is a standardized tool used to assess balance in school-age children, especially those with mild to moderate motor impairments (Appendix #3).

It includes 14 tasks, each scored from 0 to 4 points, with a total score of 56; higher scores reflect better balance. In the referenced study, the PBS showed excellent reliability, with an interclass correlation coefficient (ICC) of 0.998 for test-retest reliability and 0.997 for interrater reliability, indicating consistent results across different evaluators and times. To administer the PBS, it should be done in a quiet setting, and each task must be clearly explained to the child. Scoring is based on the child's performance, ranging from 0 (unable to perform the task) to 4 (able to perform the task independently and safely). After all tasks are completed, the scores are totaled to give a score out of 56. This total score helps assess the child's balance abilities and identify any risks for developmental delays related to balance issues. Overall, this structured method enables healthcare providers to track progress over time and customize interventions, making the PBS a valuable tool in clinical practice. (Laspa et al. 2020)

- **Cardiovascular Fitness Assessment:**

Cardiovascular endurance was evaluated using the **6-Minute Walk Test (6MWT)**, a standardized and widely recognized tool for assessing cardiovascular fitness and functional mobility (Appendix #4). The 6MWT measures the maximum distance an individual can walk within six minutes on a flat, hard surface. It is particularly valuable for individuals with Down syndrome, as it provides an objective measure of functional capacity and overall health status.

The test reflects the integrated responses of various physiological systems involved in physical exertion, including the cardiovascular, respiratory, and muscular systems, thereby serving as a reliable indicator of exercise tolerance. Additionally, the 6MWT is a safe, low-risk, and practical assessment that allows participants to walk at a self-selected pace, offering a realistic representation of everyday functional endurance (Casey, Wang, and Osterling 2012; Hamilton and Haennel 2000).

3.5.2 Study Procedures (from 6 March to 23 July 2025)

1. **Participant Recruitment**: Parents or guardians were informed about the study.
2. I**nformed Consent**: Written consent was obtained from parents or guardians before enrollment (Appendix #5).
3. **Baseline Assessment**: Children underwent baseline assessments, including demographic information (age, sex, address, weight) as well as evaluation for cardiovascular fitness, and balance (Appendix #2). The assessors were two physiotherapists from Jemima who conducted the evaluations were unaware of the participants' group assignments (intervention or control) to reduce bias in scoring and interpretation of results.
4. **Intervention Implementation**: Children participated in a structured exercise program over 12 weeks, which included cardiovascular fitness exercises such as treadmill exercises, resistance training, and balance activities. During each intervention session, the exercises were presented in a simple, game-like way (such as relays and friendly competitions) to keep children motivated and interested. The researcher used clear instructions, demonstrations, and frequent encouragement, and asked children to work in pairs or small groups to increase communication and social interaction. Parents were encouraged to help their children attend regularly and to praise their efforts at home to support confidence and continued participation.

5. **Control Group**: A control group was established to compare outcomes with those who participated in the exercise program. This group received regular physical therapy without any additional structured exercise interventions.
6. **Post-Intervention Assessment**: After completing the program, children underwent the same assessments to evaluate changes in fitness levels. The evaluators conducting post-intervention assessments were blinded to the group assignments of each child. This method helped ensure that any observed changes in fitness levels could be attributed to the intervention rather than evaluator bias.

3.6. Suggested Program

Program Overview

• Frequency: The program took place twice a week.

• Duration: Each session lasted 60 minutes, which included time for warm-up and cool-down.

• Engagement: music and games were used to make the exercises fun and promote active participation.

• There were two groups: one from the Jemima Foundation and the other from Life Gate. Tailored exercises from each type were chosen for each session to avoid fatigue and ensure that participants remained comfortable.

The table below reveals the contents of the suggested program, along with pictures that illustrate the exercises adopted and conducted in this study.

Table 3.1. A: Proposed Program Description

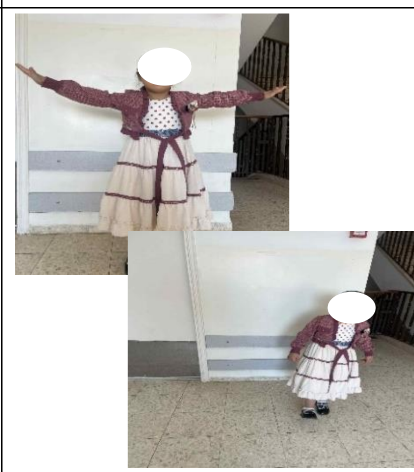
Exercise session	Type of exercise	Description	Duration /frequency	Pictures
Warm up	Dynamic stretching	Gentle movements to prepare the body (e.g., arm circles, leg swings).	5 minutes	

Table 3.1. B: Proposed Program Description

Exercise session	Type of exercise	Description	Duration /frequency	Pictures
Cardiovascular	Treadmill walking	Walking on a motorized treadmill at a comfortable place	8 minutes days/week	
	Fun relay races	Set up relay with cones to encourage running and team work.	10 minutes	
Strength training	Upper body exercise	Use light weights or resistance bands for	10 minutes	
	Burpees	Burpees are a full body exercise that combines a squat, plank, push up, and jump performing by squatting down, kicking feet back into a plank, doing a push up, jumping feet forward then explosively jumping up	3 sets of 12 repetitions	   

Table 3.1. C: Proposed Program Description

Exercise session	Type of exercise	Description	Duration /frequency	Pictures
	Jump in/ out	Jumping in and out of a designed area (like a hula hop) to improve agility	3 sets of 12 repetitions	
	Lower body exercise	Body weight exercise such as		
	Squats	Standing with feet shoulder width apart and lowering the body as if sitting in a chair	3 sets of 12 repetitions	
	Steps ups	Stepping onto a law platform or step with alternating legs	3 sets of 12 repetitions	
Balance training	Balance activities	Fun activities to enhance balance	10 minutes	
	One leg stance	Balancing on one leg while counting or singing	Hold for 10-30 seconds	

Table 3.1. D: Proposed Program Description

Exercise session	Type of exercise	Description	Duration /frequency	Pictures
	Walking on balance beam	Walking across a low beam or line on the floor	5 passes	
	Trampoline jumping	Jumping on a trampoline for fun and balance improvement	5 minutes	
	Bucket challenge	Balancing on one foot while placing balls into buckets to enhance balance skills	5minutes	
	Balloon hitting	Balancing on one foot while hitting a balloon back and forth to improve dynamic balance skills	5 minutes	

Table 3.1. E: Proposed Program Description

Exercise session	Type of exercise	Description	Duration /frequency	Pictures
	Bounce and catch	Bouncing and catching a ball while standing on one foot to develop coordination and balance	5 minutes	
Cool down	Static stretching	Gentle stretches to relax muscles (e.g. reaching for toys, arm sketches	5 minutes	

3.7. Statistical Analysis

The statistical program for the social sciences (SPSS) package, version 27 (SPSS Inc. Chicago, IL), was used to conduct the statistical analysis. Descriptive statistics and inferential statistics employing means and medians were used to analyze the data. To describe the sample, descriptive statistics were used. In inferential statistics, the difference between groups and between pre and post-tests was measured using parametric (T-tests) and nonparametric (Mann-Whitney) tests. The link between the study variables on the scales was ascertained using Pearson's correlation coefficient. The effect size was determined using Cohen's d values. The threshold for statistical significance was set at P<0.05.

3.7. Ethical Considerations

The study received ethical approval from Jemima and Life Gate as well as the Al-Quds University research ethical committee (Appendix #1 | Ref. #: 502/REC/2025). The study's goals and methods were explained to the guardians of the participants, and the data was handled discreetly. The guardians of the participants were free to decline or leave the study at any moment. The guardians of the participants signed a written consent form.

Chapter Four

Results Presentations, Analysis, and Discussion

4.1. Introduction

This chapter presents the results of the study, following analysis and interpretation of the raw data on the findings of the data collected. The findings are presented according to the objective of the study and it hypothesis, it includes the way that participants were recruited in this study, socio-demographics of the participants, and the inferential statistics.

4.2. Recruitment of Participants

As shown in Figure 4.1, a total of 40 children diagnosed with Down syndrome participated in this study. Of these, 15 children were selected from the Life Gate Association and 5 children from the Jemima Association for each group. The selection process was carried out with consideration of the children's physical health. The 20 children in the experimental group and the 20 children in the control group completed both the pre-tests and post-tests related to the study's objectives.

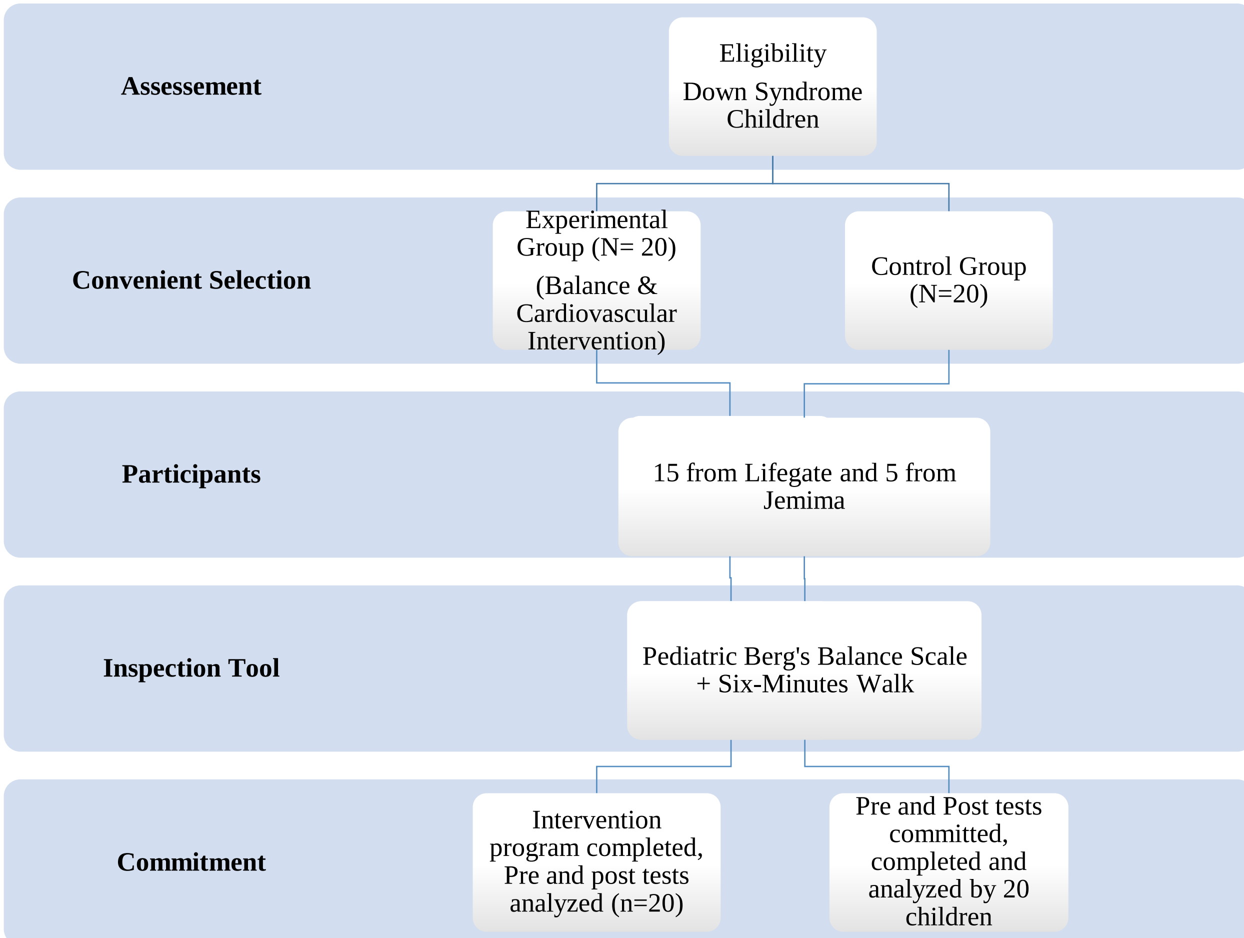


Figure 4. 1: Flowchart regarding the Selection of the Participants

4.3. Descriptive analysis of Demographics

Forty kids with Down syndrome took part in the research, divided into two groups: the experimental group included 20 children, and the control group consisted of 20 children. As shown in Table 4.1, in both groups the females were the majority (experimental=70%, control=60%). Moreover, most participants in both groups benefited from occupational therapy (65%) and speech therapy (75%), respectively.

Table 4. 1: Frequencies and Percentages of participants' Demographics in both groups

Variables	Categories	Experimental Group (n=20)		Control Group (n=20)	
		N	%	N	%
Gender	Male	6	30	8	40
	Female	14	70	12	60
Address	Bethlehem	12	60	11	55
	Hebron	7	35	7	35
	Jericho	1	5	2	10
Medical Services	Occupational Therapy	3	15	2	10
	Occupational & Speech Therapy	13	65	15	75
	All	4	20	3	15
Family Structure	1	0	0	2	10
	2	2	10	9	45
	3	7	35	7	35
	4 or more	11	55	2	10

Regarding the demographic variables, table 4.2 reveals that the mean age in the experimental group was 6.75 years, while in the control group it was 7.15 years; there were no significant differences between the groups regarding age (p-value 0.621). The study found that participants in the experimental group had a mean weight of 20.44 kg, younger mothers (37.10) and fathers (41.85), compared to the control group's 40.60 years.

Table 4. 2: Demographic Characteristics of Participants and Parents

Variables	Experimental Group (n=20)	Control Group (n=20)
	Mean ± SD	Mean ± SD
Age	6.75 ± 2.31	7.15 ± 2.74
Weight	20.44 ± 9.62	23.60 ± 8.23
Mother Age	37.10 ± 6.07	35.65 ± 5.74
Father Age	41.85 ± 6.45	40.60 ± 6.75

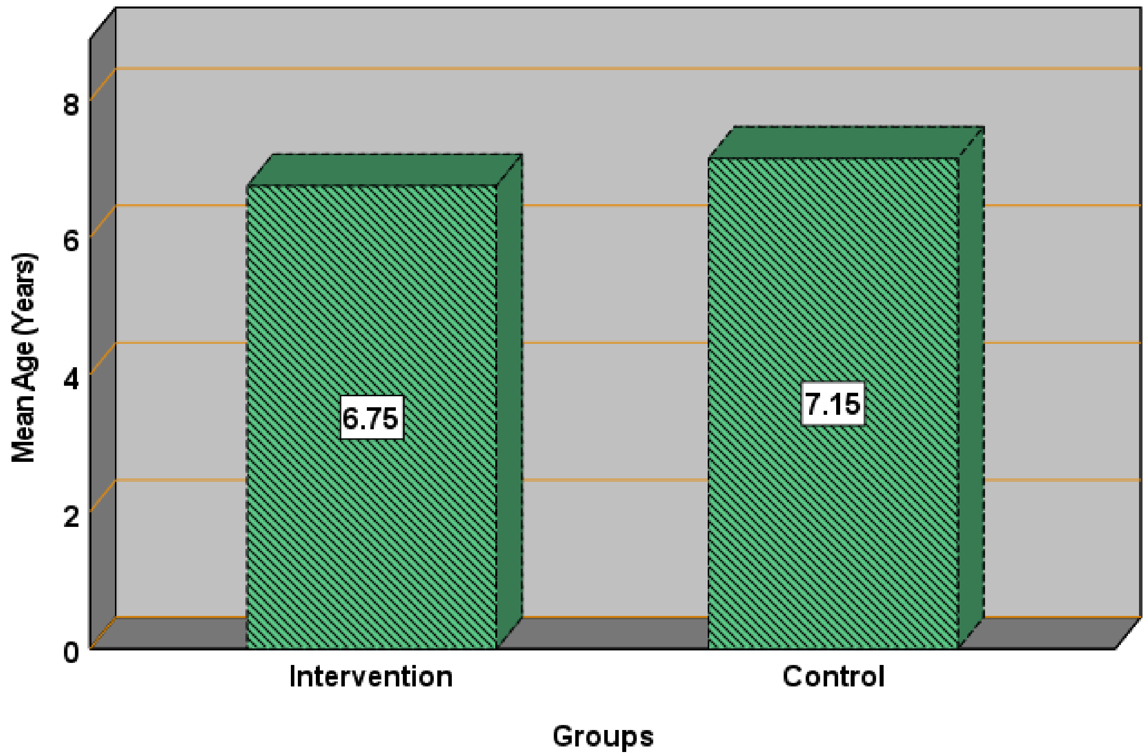


Figure 4. 2: Mean age of both intervention and control groups

4.4. Descriptive statistics of Pediatric Berg's Balance Scale

At baseline, both the experimental and control groups exhibited comparable limitations in functional mobility and balance tasks. Post-intervention, the experimental group demonstrated significantly greater improvements across multiple domains. Specifically, the proportion of participants able to rise from sitting without hand support increased from 50% to 95% in the experimental group, compared with a smaller change from 80% to 85% in the control group. Similarly, the ability to stand on one foot for 5–9 seconds improved from 15% to 50% in the experimental group, whereas only a modest increase was observed in the control group (20% to 25%). Marked improvements were also evident in dynamic balance tasks, such as turning 360 degrees (95% vs. 60% post-test) and retrieving an object from the floor (100% vs. 40% post-test).

Overall, these findings indicate that the experimental intervention elicited superior functional gains in balance, transfers, and mobility when compared with the control condition, as shown in table 4.3:

Table 4.3. A: Frequencies of Pediatric Berg Balance Scale among Participants

Items	Categories	Experimental Group (n=20)		Control Group (n=20)	
		Pre	**Post**	**Pre**	**Post**
		N (%)	**N (%)**	**N (%)**	**N (%)**
Sitting to Standing	Able to stand independently using hands	10 (50)	1 (5)	4 (20)	3 (15)
	Able to stand without using hands and stabilize independently	10 (50)	19 (95)	16 (80)	17 (85)
Standing to Sitting	Controls descent by using hands	4 (20)	4 (20)	6 (30)	4 (20)
	Sits safely with minimal use of hands	16 (80)	16 (80)	14 (70)	16 (80)
Transfers	Able to transfer with verbal cueing and/or supervision (spotting)	1 (5)	0	0	0
	Able to transfer safely: definite need of hands	8 (40)	3 (15)	8 (40)	7 (35)
	Able to transfer safely, with minor use of hands	11 (55)	17 (85)	12 (60)	13 (65)
Standing Unsupported	Unable to stand 10 seconds unassisted	1 (5)	0	0	0
	Able to stand 15 seconds unsupported	1 (5)	0	1 (5)	1 (5)
	Able to stand 30 seconds with supervision (spotting)	1 (5)	2 (10)	7 (35)	6 (30)
	Able to stand safely for 30 seconds	17 (85)	18 (90)	12 (60)	13 (65)
Sitting Unsupported	Unable to sit 10 seconds without support.	1 (5)	0	0	0
	Able to sit for 15 seconds	0	0	2 (10)	1 (5)
	Able to sit 30 seconds under supervision (spotting)	5 (25)	2 (10)	10 (50)	10 (50)
	Able to sit safely and securely for 30 seconds	14 (70)	18 (90)	8 (40)	9 (45)
Standing with eyes closed	Needs help to keep from falling	3 (15)	0	0	0
	Unable to keep eyes closed for 3 seconds, but stays steady	4 (20)	0	2 (10)	1 (5)
	Able to stand for 3 seconds	2 (10)	1 (5)	5 (25)	6 (30)
	Able to stand 10 seconds with supervision (spotting)	2 (10)	1 (5)	7 (35)	6 (30)
	Able to stand 10 seconds safely	9 (45)	18 (90)	6 (30)	7 (35)
Standing with feet together	Need help to attain a position/or unable to hold for 30 seconds	1 (5)	0	1 (5)	2 (10)

Table 4.3. B: Frequencies of Pediatric Berg Balance Scale among Participants

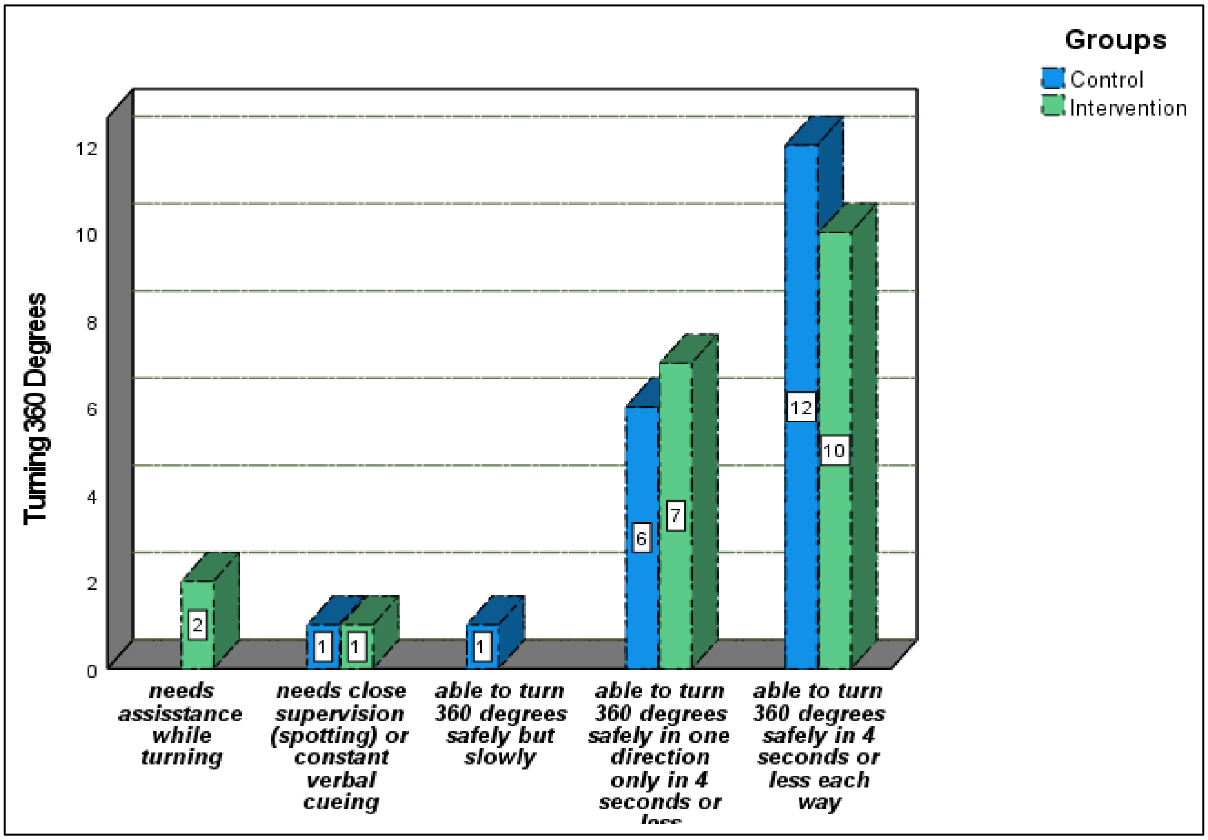
Items	Categories	Experimental Group (n=20)		Control Group (n=20)	
		Pre	**Post**	**Pre**	**Post**
		N (%)	**N (%)**	**N (%)**	**N (%)**
	Needs help to attain a position, but can stand 30 seconds with feet together	1 (5)	0	3 (15)	0
	Able to place feet together independently and stand for 30 seconds with supervision	5 (25)	1 (5)	11 (55)	12 (60)
	Able to place feet together independently and stand for 30 seconds safely	13 (65)	19 (95)	5 (25)	6 (30)
Standing with one foot in front	Needs help to step, but can hold for 15 seconds	2 (10)	0	1 (5)	1 (5)
	Able to take small steps independently and hold for 30 seconds, or require assistance to place a foot in front	6 (30)	0	7 (35)	7 (35)
	Able to place the foot ahead of the other independently and hold for 30 seconds	7 (35)	16 (80)	9 (45)	8 (40)
	Able to place feet tandem independently and hold for 30 seconds	5 (25)	4 (20)	3 (15)	4 (20)
Standing on one foot	Unable to try or needs assistance to prevent a fall	7 (35)	0	1 (5)	1 (5)
	Tries to lift leg: unable to hold 3 seconds, but remains standing	4 (20)	1 (5)	6 (30)	4 (20)
	Able to lift leg independently and hold for 3 to 4 seconds	3 (15)	5 (25)	9 (45)	9 (45)
	Able to lift leg independently and hold for 5 to 9 seconds	3 (15)	10 (50)	4 (20)	5 (25)
	Able to lift leg independently and hold for 10 seconds	3 (15)	4 (20)	0	1 (5)
Turning 360 Degrees	Needs assistance while turning	2 (10)	0	0	0
	Needs close supervision (spotting) or constant verbal cueing	1 (5)	0	1 (5)	0
	Able to turn 360 degrees safely in one direction only in 4 seconds or less, and completes a turn in the other direction	7 (35)	0	6 (30)	7 (35)
	Able to turn 360 degrees safely in 4 seconds or less each way	10 (50)	19 (95)	12 (60)	12 (60)
	Able to turn 360 degrees safely but slowly	0	1 (5)	1 (5)	1 (5)

Table 4.3. C: Frequencies of Pediatric Berg Balance Scale among Participants

Items	Categories	Experimental Group (n=20)		Control Group (n=20)	
		Pre	**Post**	**Pre**	**Post**
		N (%)	**N (%)**	**N (%)**	**N (%)**
Turning to look behind	Needs assistance to keep losing balance or falling: movement of the chin is less than half the distance to the shoulder	1 (5)	0	0	0
	Needs supervision (spotting) when turning: the chin moves greater than half the distance to the shoulder	1 (5)	0	0	0
	Look behind/over one shoulder with trunk rotation: weight shift in the opposite direction to the level of the shoulder	7 (35)	1 (5)	11 (55)	11 (55)
	Look behind/over each shoulder: weight shifts include trunk rotation	11 (55)	18 (90)	8 (40)	8 (40)
	Turn your head to look at the level of the shoulder	0	1 (5)	1 (5)	1 (5)
Retrieving an object from the floor	Unable to pick up the eraser, but reaches 1 to 2 inches from the eraser and keeps balance independently	2 (10)	0	3 (15)	2 (10)
	Able to pick up an eraser but needs supervision (spotting)	4 (20)	0	10 (50)	10 (50)
	Able to pick up an eraser safely and easily	14 (70)	20 (100)	7 (35)	8 (40)
Placing the alternate foot on the stool	Needs assistance to maintain balance or keep from falling, unable to try	2 (10)	0	0	0
	Able to complete 2 steps: needs minimal assistance	1 (5)	0	0	0
	Able to complete 4 steps without assistance, but requires close supervision (spotting)	4 (20)	1 (5)	6 (30)	6 (30)
	Able to stand independently and complete 8 steps >20 seconds	8 (40)	7 (35)	10 (50	9 (45)
	Stands independently and safely and completes 8 steps in 20 seconds	5 (25)	12 (60)	4 (20)	5 (25)
Reaching forward with an outstretched arm	Reaches forward but needs supervision (spotting)	2 (10)	0	4 (20)	4 (20)
	Can reach forward > 2 inches, safely	3 (15)	0	3 (15)	3 (15)
	Can reach forward >5 inches, safely	8 (40)	7 (35)	11 (55)	11 (55)
	Can reach forward confidently > 10 inches	7 (35)	13 (65)	2 (10)	2 (10)

Figure 4.3 shows the frequencies among children within each category of the Turning 360 Degree variable among the pre-test, in which 12 children in the control group were able to turn 360 degrees safely in 4 seconds or less each way, while 10 children in intervention group.

Figure 4. 3: Frequency of Children within the item "Turning 360 Degrees" in both Groups



among the Pediatric Berg's Balance Scale (Pre-test)

While, figure 4.4 shows that in post-test of turning 360 degrees variable, 19 children in the intervention group were able to turn 360 degrees safely in 4 seconds or less each way, while 12 children in control group.

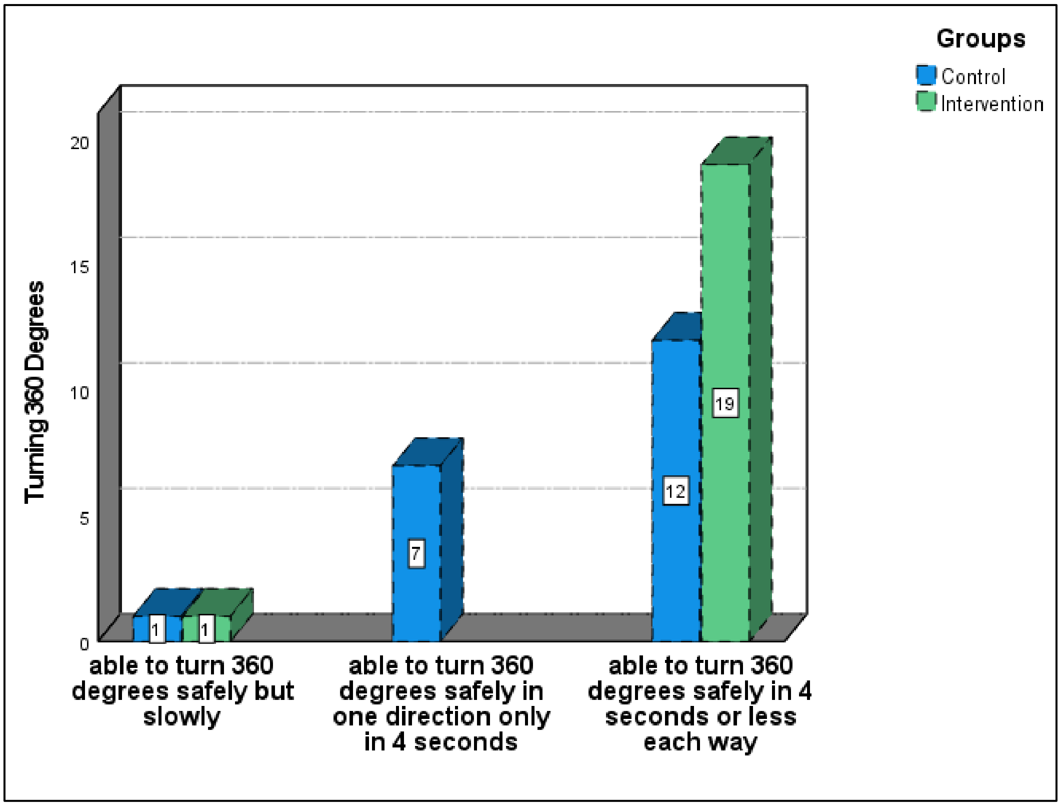


Figure 4. 4: Frequency of Children within the item "Turning 360 Degrees" in both Groups among the Pediatric Berg's Balance Scale (Post-test)

Moreover, figure 4.5 and figure 4.6 reveal the changing freqeuncies among downsyndorme children participated in the study within both groups between pre-test and post test of the variable "Standing on one Foot", as following:

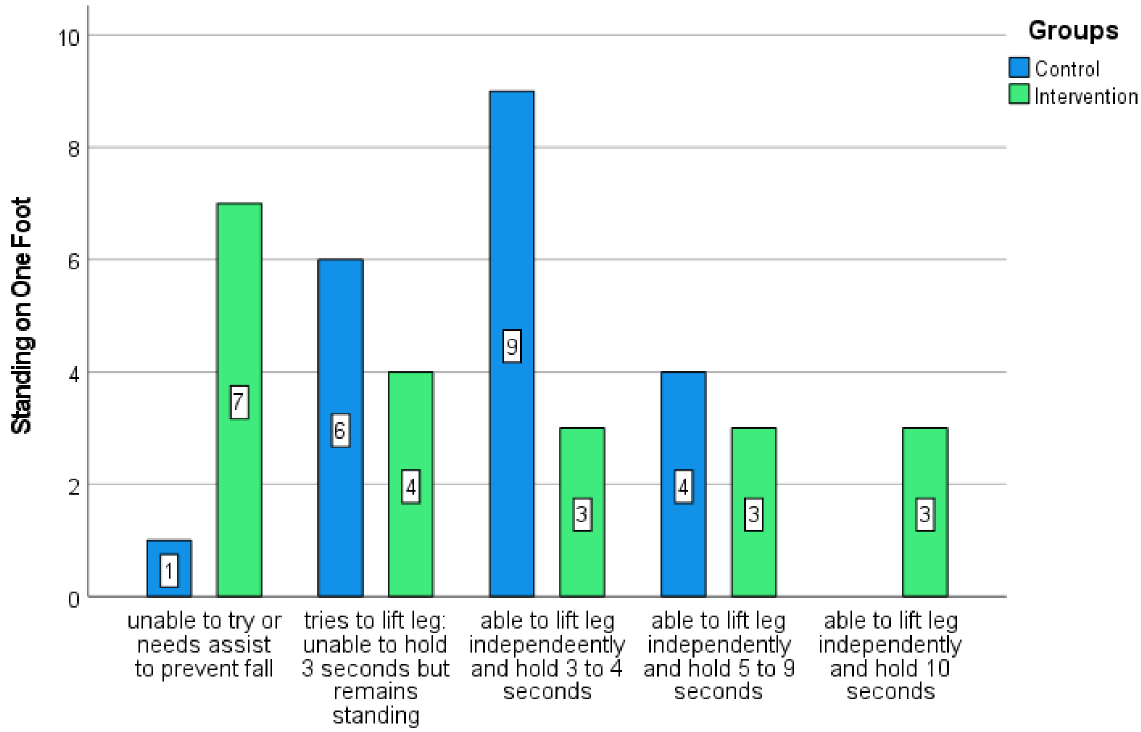


Figure 4. 5: Frequency of Children within the item "Standing on one Foot" in both Groups among the Pediatric Berg's Balance Scale (Pre-test)

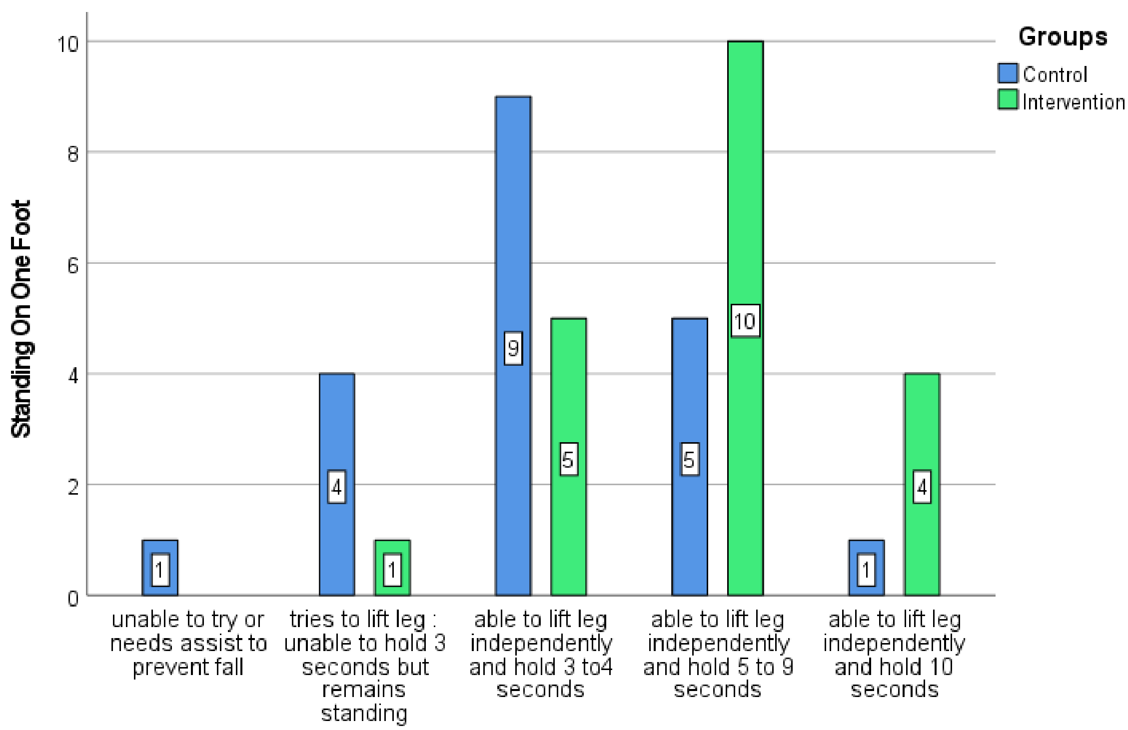


Figure 4. 6: Frequency of Children within the item "Standing on one Foot" in both Groups among the Pediatric Berg's Balance Scale (Post-test

4.5. Normality tests of the Data

The Kolmogorov-Smirnov and Shapiro-Wilk tests were conducted to examine the normality of the data collected in this study. Given that the Shapiro-Wilk test is more appropriate for small sample sizes (n < 50), its results were primarily considered in assessing the distribution of the variables. As presented in Table 4.4, the six-minutes-walk test pre and post variables did not follow a normal distribution, as their p-values were less than 0.05. The only exception was the variable "PBBS-Pre," which demonstrated a normal distribution (p = 0.445). Based on these findings, both non-parametric and parametric statistical tests were subsequently employed, depending on the distribution characteristics of each variable.

Table 4. 4: Results of Normality tests

	Kolmogorov-Smirnov[a]			Shapiro-Wilk		
	Statistic	**df**	**Sig.**	**Statistic**	**df**	**Sig.**
PBBS- pre	0.090	40	0.200*	0.973	40	0.445
PBBS- post	0.192	40	0.001	0.867	40	<0.001
Six-minutes-walk- pre	0.185	40	0.001	0.890	40	0.001
Six-minutes-walk- post	0.139	40	0.050	0.935	40	0.023

4.6. Inferential Statistics for Variables

4.6.1 Pediatric Berg's Balance Scale

As shown in Table 4.5 and Figure 4.3, no statistically significant difference was found between the two groups in the Pediatric Berg Balance Scale (PBBS) pre-test (p = 0.941). However, in the PBBS post-test, a statistically significant difference was observed between the groups (p = 0.001). In which the interventional group revealed a highly significant improvement within a very large effect size (Cohen's D = 1.447).

Table 4. 5: Pre- and Post-Test Results of the Pediatric Berg Balance Scale (PBBS) in Intervention (N=20) and Control Groups (N=20)

Categories	Groups	Mean ± SD	Median	P-Value	95% Confidence Interval of the Difference	
					Lower	Upper
PBBS- Pre	Intervention	43.95 ± 6.03	43	0.941	-4.21	3.91
	Control	44.10 ± 6.65	44.5			
PBBS- Post	Intervention	52.10 ± 2.81	53.5	0.001	4.05	10.50
	Control	44.85 ± 6.50	45			

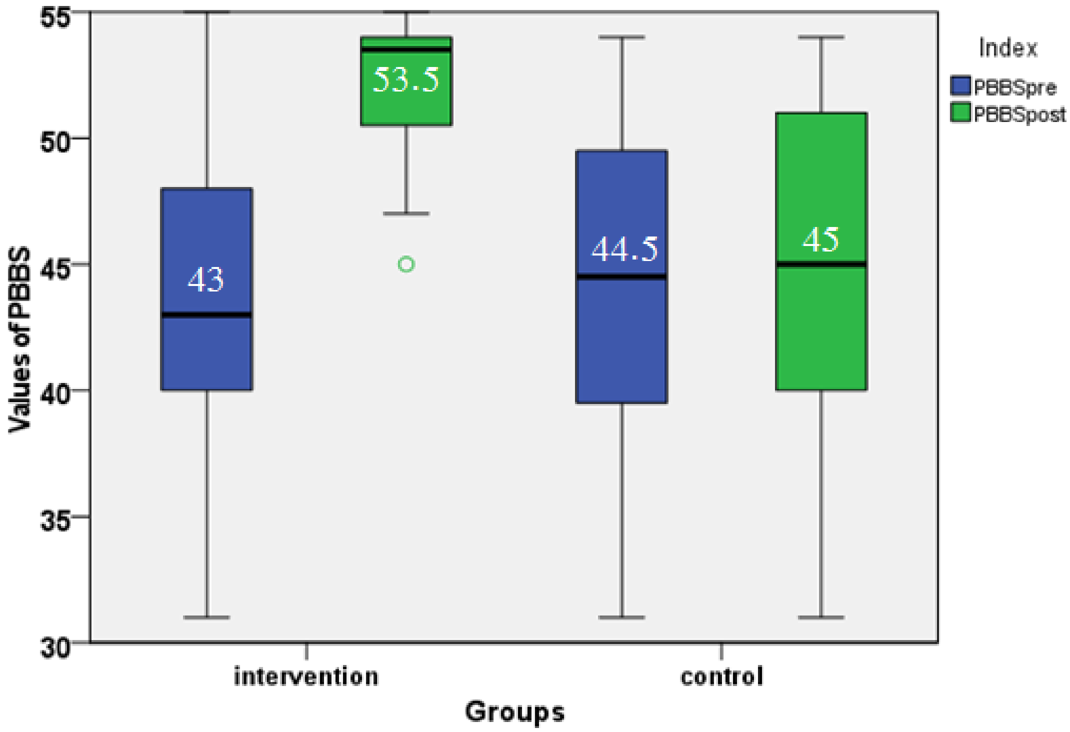


Figure 4. 7: Median Values of Pediatric Berg's Balance Scale (Pre & Post) for Both Groups

4.6.2 Six-Minutes-Walk Test

The results in Table 4.6 and Figure 4.4 showed that there were no significant statistical differences in the Six-Minute Walk pre-test between both groups (p-value 0.521). While significant statistical differences were found in the post-test of Six-Minute Walk between both groups (p< 0.001). In which the intervention group revealed significant improvements in the Six-Minute Walk post-test within an extremely large effect size (Cohen's D= 3.433).

Table 4. 6: Pre- and Post-Test Results of the Six-Minutes-Walk in Intervention and Control Groups

Categories	Groups	Mean ± SD	Median	P-Value	Means Diff.	95% Confidence Interval of the Difference	
						Lower	Upper
Six-Minutes-Walk- Pre	Intervention	174.15 ± 25.85	165	0.521	-7.85	-32.57	16.87
	Control	182.00 ± 47.50	165				
Six-Minutes-Walk- Post	Intervention	368.00 ± 55.85	360	<0.001	181.00	147.23	214.77
	Control	187.00 ± 49.40	167.5				

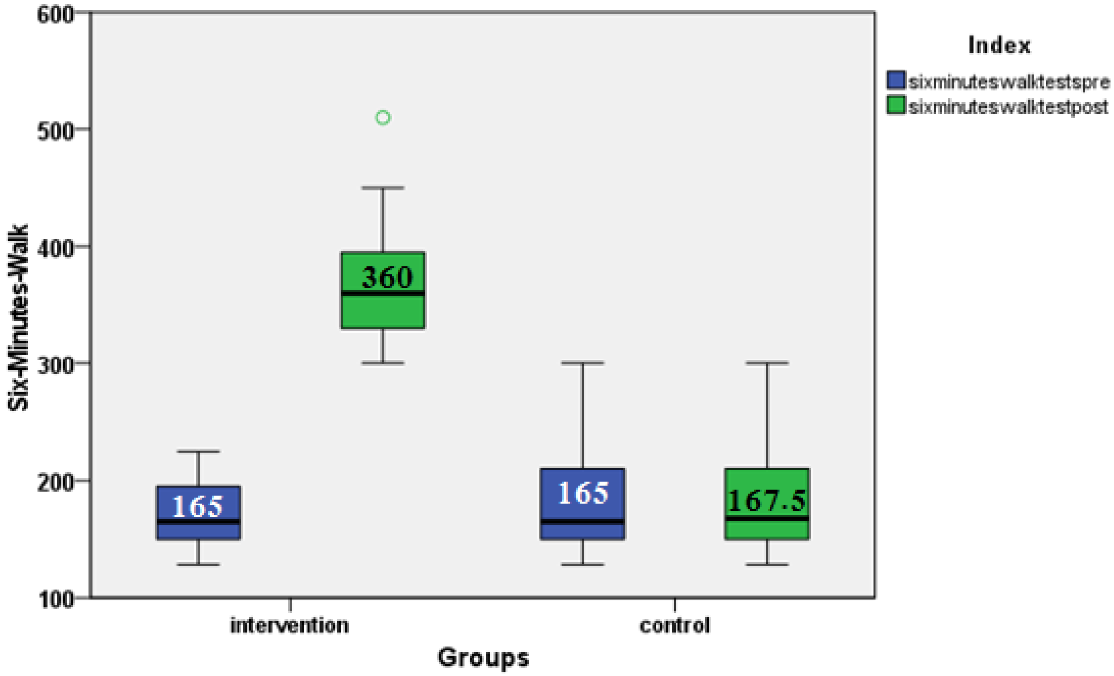


Figure 4. 8: Median Values of Six-Minutes-Walk test (Pre & Post) for Both Groups

4.6.3 Differences between variable scores (Pre-Post tests) among both Groups

Table 4.7 indicated that significant statistical differences were found between pre and post-tests regarding the Berg's Balance scale, in the intervention group (p <0.001). While there are no significant statistical differences found between pre-and post-tests regarding the Berg's balance scale among the participants in the control group (p-value= 0.074).

Table 4. 7: Differences in the variable "PBBS" in the same group (pre & post)

Group	Pairs	Variables	Mean ± SD	T-value	Df	P-value
Intervention	Pair 1	PBBS- Pre	-8.15 ± 6.01	-6.06	19	<0.001
		PBBS- Post				
Control	Pair 1	PBBS- Pre	-0.75 ± 1.77	-1.89	19	0.074
		PBBS- Post				

Moreover, table 4.8 revealed that there are significant statistical differences between the pre- and post-tests regarding the six-minute walk test among the participants in the intervention group (p <0.001). While there are no significant statistical differences found between pre-and post-tests regarding the six-minute walk test, among the participants in the control group (p-value= 0.106).

Table 4. 8: Differences in the variable "Six-minute walk" in the same group (pre & post)

Group	Pairs	Variables	Mean ± SD	T-value	Df	P-value
Intervention	Pair 2	Six-minutes-walk- Pre	-193.85 ± 63.55	-13.64	19	<0.001
		Six-minutes-walk-Post				
Control	Pair 2	Six-minutes-walk-Pre	-5.00 ± 13.18	-1.69	19	0.106
		Six-minutes-walk-Post				

4.6.4 Correlation Between Pediatric Berg's Balance Scale and Six-Minutes-Walk test (Post-test)

In this section, the correlation between post-tests among Pediatric Berg's Balance Scale and Six-minutes-walk test has been conducted. Accordingly, table 4.9 revealed that there is a strong positive relationship between both variables within the post-test (R= 0.663, p < 0.001). This indicates that when the score of Pediatric Berg's Balance scale increased, the score of six-minutes-walk test will increase.

Table 4. 9: Results of Spearman Correlation Coefficient for the relationship between PBBS and Six-minutes-Walk test

		PBBS post	Six-minutes-walk post
PBBS post	**Correlation Coefficient**	1.000	0.663^{**}
	P-Value	.	<0.001
	N	40	40
Six-minutes-walk post	**Correlation Coefficient**	0.663^{**}	1.000
	P-Value	<0.001	.
	N	40	40

4.7. Discussion

The primary objective of this study was to examine the effectiveness of a structured exercise program that combined aerobic and balance training in enhancing cardiovascular fitness and balance among children with Down syndrome. This research represents the first study of its kind in Palestine to focus specifically on the implementation and evaluation of a structured exercise intervention for this population. It was hypothesized that children who participated in the exercise program would demonstrate significantly greater improvements in both cardiovascular fitness and balance compared to those in the control group.

Regarding the balance outcomes, the findings align with previous research suggesting that multimodal exercise interventions yield greater improvements in balance performance than programs emphasizing a single exercise modality (Lei et al. 2025). In the present study, a statistically significant improvement was observed in the Pediatric Berg Balance Scale (PBBS) post-test scores between the experimental and control groups. The experimental group exhibited a highly significant improvement with a large effect size (Cohen's d = 1.447), indicating substantial gains in postural control encompassing both dynamic and static balance. These results underscore the effectiveness of integrated exercise programs in promoting functional stability and motor control among children with Down syndrome.

Furthermore, the findings of the present study revealed a statistically significant difference in the post-test results of the Six-Minute Walk Test (6MWT) between the experimental and control groups (p = 0.000). The experimental group demonstrated a marked improvement, with an extremely large effect size (Cohen's d = 3.433), indicating a substantial enhancement in cardiovascular endurance following participation in the structured exercise program.

These results are consistent with previous research showing that aerobic exercise not only improves cardiovascular function but also promotes sustained engagement in physical activity**,** which is crucial for maintaining long-term health in individuals with Down syndrome (Bahiraei, 2023). Similarly, (Gupta 2024a) reported that aerobic training has a significant positive impact on cardiovascular outcomes, supporting the efficacy of multifaceted interventions that combine different exercise modalities.

Consistent with our results, earlier evidence from a randomized controlled trial demonstrated that exercise programs can lead to significant improvements in both static and dynamic balance among children with Down syndrome (Maïano et al. 2019).. Complementing this, a systematic review by (Muñoz-Llerena et al. 2024b) concluded that structured exercise interventions enhance cardiovascular health in this population.

Taken together, these findings along with those of the present study indicate a strong positive correlation between balance and cardiovascular fitness**,** suggesting that improvements in one domain can facilitate concurrent gains in the other. This interdependence highlights the comprehensive benefits of structured, multimodal exercise programs in promoting overall physical functioning and well-being among children with Down syndrome.

Previous research supports this integrated approach. For instance, (Casey et al. 2014) demonstrated that combined aerobic and balance training significantly enhances physical fitness and functional abilities in individuals with Down syndrome. Similarly, (Vandoni et al. 2023) emphasized that improvements in physical activity not only foster better physical outcomes but also contribute to an improved quality of life and a reduced caregiver burden**.**

Parental and social factors likely contributed to the effectiveness of this program. Parents of children with Down syndrome frequently highlight their role in encouraging their children, providing practical support, and organizing daily routines to ensure consistent participation in physical activity (Alghamdi et al. 2021) Moreover, engagement in enjoyable, socially inclusive activities is associated with gains in mood, confidence, and social skills, which may foster sustained involvement in both structured exercise and routine daily tasks.(Merzbach et al. 2024b)

In conclusion, the present study reinforces the substantial benefits of structured exercise programs that integrate both balance and cardiovascular components. Such programs extend beyond improving physiological health—they also foster greater functional independence**,** enhance motor coordination**,** and encourage more active participation in daily activities. Collectively, these outcomes underscore the importance of implementing evidence-based, comprehensive exercise interventions as a cornerstone of rehabilitation and health promotion for individuals with Down syndrome.

4.8. Study Limitations

- The ongoing conflict in Palestine posed substantial challenges to participant recruitment and the consistent delivery of intervention sessions, potentially impacting the continuity of the study and its overall outcomes.
- Given that children with Down syndrome often have reduced physical endurance and energy levels, the study intentionally minimized the number of assessment procedures to uphold ethical research standards and reduce participant fatigue throughout the intervention process.
- Maintaining participant motivation and engagement in the structured exercise program proved to be a continual challenge. Children with Down syndrome frequently demonstrate decreased endurance and shorter attention spans, which can negatively influence consistency and adherence to scheduled intervention sessions.

- The limited sample size in this study can be attributed, in part, to the prevailing social stigma surrounding participation in structured physical activity programs for children with disabilities, which restricted enrollment and broader community involvement.

Chapter Five

Conclusion & Recommendations

5.1 Conclusions

- There was a statistically significant improvement in cardiovascular endurance in the intervention group, as measured by the six-minute walk test ($p = 0.001$), with very large effect size (Cohen's $d = 3.433$)
- The intervention group showed a significant improvement in balance, as assessed by the pediatric berg balance scale ($p = 0.001$), with a large effect size (Cohen's $d = 1.447$), compared to the control group.
- the intervention group showed clear gains in the specific balance tasks, especially in difficult items such as turning 360 degrees and standing on one foot post intervention ($p = 0.001$).
- A strong, positive correlation was found between the six-minute' walk test and berg balance scale at post -test ($r = 0.663$, $p = 0.001$), indicating improvement in cardiovascular fitness were associated with better balance performance.
- There was limited improvement observed in the control group; however, these changes were not statistically significant for either outcome measure ($p > 0.05$).

5.2 Recommendations

Recommendations for Physiotherapists

- Implement structured exercise programs that combine aerobic and balance training for children with Down syndrome to improve both cardiovascular endurance and balance.

- Include challenging balance tasks, such as turning 360 degrees and standing on one foot, to target specific postural control skills.

- Monitor cardiovascular and balance improvements concurrently, as gains in one domain are likely to support progress in the other.

- Encourage consistent participation and motivation, adapting sessions to the child's endurance and attention span to maximize adherence and outcomes.
- Consider using standardized outcome measures such as the Six-Minute Walk Test and Pediatric Berg Balance Scale to track progress objectively

Recommendations for Researchers

- Conduct larger-scale studies to confirm the effectiveness of combined aerobic and balance interventions in children with Down syndrome.
- Investigate the long-term effects of structured exercise programs on functional independence and quality of life.
- Explore the mechanisms underlying the correlation between cardiovascular fitness and balance improvements to inform intervention design.
- Examine strategies to overcome barriers to participation, including social stigma and limited accessibility, to increase recruitment and retention.
- Consider multicenter studies or community-based interventions to enhance generalizability and evaluate program feasibility in diverse settings.

Recommendations for Rehabilitation Policymakers

- Promote community-based inclusive recreational and therapeutic programs that engage children with Down syndrome alongside their peers. Such initiatives foster social inclusion, enhance emotional well-being, and provide opportunities for peer interaction.
- Recognize that community programs complement formal rehabilitation services, particularly in regions where access to specialized care is limited, ensuring that children continue to receive therapeutic support outside clinical settings.
- Encourage collaboration between rehabilitation centers, schools, and community organizations to implement evidence-based, structured interventions that address both physical fitness and functional skills.
- Establish policy guidelines and standards for inclusive programs, including staff training, safety protocols, and regular monitoring of program effectiveness to ensure quality and sustainability.
- Support public awareness campaigns to reduce stigma and increase community participation, highlighting the benefits of inclusive recreational and therapeutic activities for children with Down syndrome.

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Appendices:

Appendix #1: Research Ethics Committee's Decision Letter

Al-Quds University
Jerusalem
Deanship of Scientific Research

بسم الله الرحمن الرحيم

جامعة القدس
القدس
عمادة البحث العلمي

Research Ethics Committee
Committee's Decision Letter

Date: February 16, 2025
Ref No: 502/REC/2025

Dears Dr. Hadeel Halaweh, Ms. Razan hilal,

Thank you for submitting your application seeking approval for research ethics. After a thorough review of your submission titled "The Effect of a Suggested Exercise Program on Balance and Cardiovascular Fitness in Children with Down Syndrome", the Research Ethics Committee (REC) at Al-Quds University is pleased to confirm that your application aligns with our research ethics guidelines.
Please be aware that while this approval authorizes your research, it does not replace any departmental or other necessary approvals. These may include permissions for sample shipment, data sharing, or administrative approval to distribute questionnaires.

Additionally, we kindly request that you provide us with a copy of your final research report or publication once it is available.

Thank you once again for your commitment to conducting ethical research. We extend our best wishes for a productive research endeavor that benefits your research subjects.

Please note that this ethical approval letter is valid for two years from the date of issuance.
If your research extends beyond this timeframe, a renewal request will be necessary. This approval remains valid as long as there are no changes to the data collection procedures or any aspect of the research protocol.

Sincerely,

Suheir Ereqat, PhD
Associate Professor of Molecular Biology
Suheir Ereqat
Research Ethics Committee Chair

Cc. Prof. Imad Abu Kishek - President
Cc. Members of the committee
Cc. file

Abu-Dies, Jerusalem P.O.Box 20002
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تلفاكس: 2791293-02-970#

Appendix #2: Demographic Data Questionnaire for Down Syndrome

Section 1: Individual Information

Age of Individuals with Down Syndrome

Please select the age range:

- 0-5 years
- 6-12 years
- 13-18 years

Sex of Individual with Down Syndrome

- Male
- Female

Ethnicity of Individual with Down Syndrome

- Palestinian
- Other (please specify): ___________

Address

- Please provide the address: ___________

Section 2: Health and Medical Information

Current Health Conditions

- Please list any current health conditions: ___________

Medical Services Received

- Speech therapy
- Occupational therapy
- Physical therapy
- Other (please specify): ___________

Weight

- Please provide the weight in kilograms: ___________

Section 3: Parent/Guardian Information

Mother's Age

Please select the age range:

- ○ 20-29 years
- ○ 30-39 years
- ○ 40-49 years
- ○ 50-59 years
- ○ 60-69 years

Father's Age

Please select the age range:

- ○ 20-29 years
- ○ 30-39 years
- ○ 40-49 years
- ○ 50-59 years
- ○ 60-69 years

Family Structure

How many siblings does the individual have?

- ○ 0
- ○ 1
- ○ 2
- ○ 3
- ○ 4 or more

Appendix #3: Pediatric Berg's Balance Scale

Name: Date:

Location: Examiner:

		Item Description Score *0-4*	Seconds *optional*
1.	Sitting to standing	______	
2.	Standing to sitting	______	
3.	Transfers	______	
4.	Standing unsupported	______	______
5.	Sitting unsupported	______	______
6.	Standing with eyes closed	______	______
7.	Standing with feet together	______	______
8.	Standing with one foot in front	______	______
9.	Standing on one foot	______	______
10.	Turning 360 degrees	______	______
11.	Turning to look behind	______	
12.	Retrieving object from floor	______	
13.	Placing alternate foot on stool	______	______
14.	Reaching forward with outstretched arm Total Test **Score**	______	
		______	

General Instructions

1. Demonstrate each task and give instructions as written. A child may receive a practice trial on each item. If the child is unable to complete the task based on their ability to understand the directions, a second practice trial may be given. Verbal and visual directions may be clarified through the use of physical prompts.

2. Each item should be scored utilizing the 0 to 4 scale. Multiple trials are allowed on many of the items. The child's performance should be scored based upon the lowest criteria, which describes the child's best performance. If on the first trial a child receives the maximal score of 4, additional trials need not be administered. Several items require the child to maintain a given position for a specific time. Progressively, more points are deducted if the time or distance requirements are not met; if the subject's performance warrants supervision; or if the subject touches an external support or receives assistance from the examiner. Subjects should understand that they must maintain their balance while attempting the tasks. The choice, of which leg stand on or how far to reach, is left to the subject. Poor judgment will adversely influence the performance and the scoring. In addition to scoring items 4, 5, 6, 7, 8, 9,10, and 13, the examiner may choose to record the exact time in seconds.

Equipment

The Pediatric Balance Scale was designed to require minimal use of specialized equipment. The following is a complete list of items required for administration of this tool:

Adjustable height bench
Chair with back support and armrests
Stopwatch or watch with a second hand
Masking tape- 1inch wide
Step stool 6 inches in height
Chalkboard eraser
Ruler or yardstick
a small level

The following items are optional and may be helpful during test administration:
2 child-size
Footprints blindfold
A brightly colored object of at least two inches in size
Flash cards
2 inches of adhesive-backed hook Velcro
Two 1 foot strips of loop Velcro
****

1. Sitting To Standing

<u>Special instruction</u>: *Items #1 and #2 may be tested simultaneously if, in the determination of the examiner, it will facilitate the best performance of the child.*
<u>INSTRUCTIONS</u>: **Child is asked to "Hold arms up and stand up."** The child is allowed to select the position of his/her arms.

<u>EQUIPMENT</u>: A bench of appropriate height to allow the child's feet to rest supported on the floor with the hips and knees maintained in 90 degrees of flexion.

<u>Best Of Three Trials</u>

- ○ 4 able to stand without using hands and stabilize independently
- ○ 3 able to stand independently using hands
- ○ 2 able to stand using hands after several tries
- ○ 1 needs minimal assist to stand or to stabilize
- ○ 0 needs moderate or maximal assist to stand

2. Standing To Sitting

Special instruction: *Items #1 and #2 may be tested simultaneously if, in the determination of the examiner, it will facilitate the best performance of the child.*
INSTRUCTIONS: **Child is asked to sit down slowly, without use of hands.** The child is allowed to select the position of his/her arms.
EQUIPMENT: A bench of appropriate height to allow the child's feet to rest supported on the floor with the hips and knees maintained in 90 degrees of flexion.
Best Of Three Trials

- ○ 4 sits safely with minimal use of hands
- ○ 3 controls descent by using hands
- ○ 2 uses back of legs against chair to control descent
- ○ 1 sits independently, but has uncontrolled descent
- ○ 0 needs assistance to sit

3. Transfers

INSTRUCTIONS: Arrange chair(s) for a stand pivot transfer, touching at a forty-five degree angle. **Ask the child to transfer one way toward a seat with armrests and one way toward a seat without armrests.**
Equipment: Two chairs, or one chair and one bench. One seating surface must have armrests. One chair/bench should be of standard adult size and the other should be of an appropriate height to allow the child to conformably sit with feet supported on the floor and ninety degrees of hip and knee flexion.
Best Of Three Trials

- ○ 4 able to transfer safely with minor use of hands
- ○ 3 able to transfer safely; definite need of hands
- ○ 2 able to transfer with verbal cueing and/or supervision (spotting)
- ○ 1 needs one person to assist
- ○ 0 needs two people to assist or supervise (close guard) to be safe

4. Standing Unsupported

INSTRUCTIONS: **The child is asked to stand for 30 SECONDS without holding on or moving his/her feet.** A taped line or footprints may be placed on the floor to help the child maintain a stationary foot position. The child may be engaged in non-stressful conversation to maintain attention span for thirty seconds. Weight shifting and equilibrium responses in feet are acceptable; movement of the foot in space *(*off the support surface) indicates end of the timed trial.
EQUIPMENT: a stop watch or watch with a second hand a twelve inch long, masking tape line or two footprints placed shoulder width apart

- ○ 4 able to stand safely 30 SECONDS
- ○ 3 able to stand 30 SECONDS with supervision (spotting)
- ○ 2 able to stand 15 SECONDS unsupported
- ○ 1 needs several tries to stand 10 SECONDS unsupported
- ○ 0 unable to stand 10 SECONDS unassisted

__________**Time in seconds**

Special Instructions: If a subject is able to stand 30 SECONDS unsupported, score full points for sitting unsupported. Proceed to item #6

5. Sitting With Back Unsupported and Feet Supported On The Floor

INSTRUCTIONS: **Please sit with arms folded on your chest for 30 SECONDS.** Child may be engaged in non-stressful conversation to maintain attention span for thirty seconds. Time should be stopped if protective reactions are observed in trunk or upper extremities.
EQUIPMENT: a stop watch or watch with a second hand, a bench of appropriate height to allow the feet to rest supported on the floor with the hips and knees maintained in ninety degrees of flexion.

- 4 able to sit safely and securely 30 SECONDS
- 3 able to sit 30 SECONDS under supervision (spotting) or may require definite use of upper extremities to maintain sitting position
- 2 able to sit 15 SECONDS
- 1 able to sit 10 SECONDS
- 0 unable to sit 10 SECONDS without support

__________ **Time in seconds**

6. Standing Unsupported With Eyes Closed

INSTRUCTIONS: The child is asked to stand still with feet shoulder width apart and close his/her eyes for ten seconds. **Direction: "When I say close your eyes, I want you to stand still, close your eyes, and keep them closed until I say open."** If necessary, a blindfold may be used. Weight shifting and equilibrium responses in the feet are acceptable; movement of the foot in space {off the support surface) indicates end of timed trial. A taped line or footprints may be placed on the floor to help the child maintain a stationary foot position.
EQUIPMENT: a stop watch or watch with a second hand, a twelve-inch long masking tape line or two footprints placed shoulder width apart blindfold
Best Of 3 Trials.

- 4 able to stand 10 seconds safely
- 3 able to stand 10 seconds with supervision (spotting)
- 2 able to stand 3 seconds
- 1 unable to keep eyes closed 3 seconds but stays steady
- 0 needs help to keep from falling

____________ **Time in seconds**

7. Standing Unsupported With Feet Together

INSTRUCTIONS: **The child is asked to place his/her feet together and stand still without holding on.** The child may be engaged in non-stressful conversation to maintain attention span for thirty seconds. Weight shifting and equilibrium responses in feet are acceptable; movement of the foot in space (off the support surface) indicates end of timed trial. A taped line or footprints may be placed on the floor to help the child maintain stationary foot position.
EQUIPMENT: a stop watch or watch with a second hand, a twelve inch long masking tape line or two footprints placed together

- 4 able to place feet together independently and stand 30 seconds safely
- 3 able to place feet together independently and stand for 30 seconds with supervision (spotting)
- 2 able to place feet together independently but unable to hold for 30 seconds
- 1 needs help to attain position but able to stand 30 seconds with feet together
- 0 needs help to attain position and/or unable to hold for 30 seconds

____________ **Time in seconds**

8. Standing Unsupported One Foot In Front

INSTRUCTIONS: **The child is asked to stand with one foot in front of the other, heel to toe.** If the child cannot place feet in a tandem position (directly in front), they should be asked to step forward far enough to allow the heel of one foot to be placed ahead of the toes of the stationary foot. A taped line and/or footprints may be placed on the floor to help the child maintain a stationary foot position. In addition to a visual demonstration, a single physical prompt (assistance with placement) may be given. The child may be engaged in non-stressful conversation to maintain his/her attention span for 30 seconds. Weight shifting and/or equilibrium reactions in the feet are acceptable. Timed trials should be stopped if either foot moves in space (leaves the support surface) and/or upper extremities support is utilized.

EQUIPMENT: a stop watch or watch with a second hand, a twelve inch long masking tape line or two footprints placed heel to toe

Best Of Three Trials

- ○ 4 able to place feet tandem independently and hold 30 seconds
- ○ 3 able to place foot ahead of other independently and hold 30 seconds. Note: The length of the step must exceed the length of the stationary foot and the width of the stance should approximate the subject's normal stride width.
- ○ 2 able to take small step independently and hold 30 seconds, or required assistance to place foot in front, but can stand for 30 seconds.
- ○ 1 needs help to step, but can hold 15 seconds
- ○ 0 loses balance while stepping or standing

______ **Time in seconds**

9. Standing On One Leg

INSTRUCTIONS: **The child is asked to stand on one leg for as long as he/she is able to without holding on.** If necessary the child can be instructed to maintain his/her arms (hands) on his/her hips (waist). A taped line or footprints may be placed on the floor to help the child maintain a stationary foot position. Weight shifting and/or equilibrium reactions in the feet are acceptable. Timed trials should be stopped if the weight-bearing foot moves in space (leaves the support surface), the up limb touches the opposite leg or the support surface and/or upper extremities are utilized for support.

EQUIPMENT: a stop watch or watch with a second hand, a twelve inch long masking tape line or two footprints placed heel to toe

3 Trials Average Score

- ○ 4 able to lift leg independently and hold 10 seconds
- ○ 3 able to lift leg independently and hold 5 to 9 seconds
- ○ 2 able to lift leg independently and hold 3 to 4 seconds
- ○ 1 tries to lift leg; unable to hold 3 seconds but remains standing
- ○ 0 unable to try or needs assist to prevent fall.

10. Turn 360 Degrees

INSTRUCTIONS: The child is asked to turn completely around in a full circle, STOP, and then turn a full circle in the other direction.
EQUIPMENT: A stop watch or watch with a second hand

- ○ 4 able to turn 360 degrees safely in 4 seconds or less each way (total of less than eight seconds)
- ○ 3 able to turn 360 degrees safely in one direction only in 4 seconds or less completes turn in other direction requires more than four seconds
- ○ 2 able to turn 360 degrees safely but slowly
- ○ 1 needs close supervision (spotting) or constant verbal cueing
- ○ 0 needs assistance while turning

______ **Time in seconds**

11. Turning To Look Behind Left & Right Shoulders While Standing Still

INSTRUCTIONS: The child is asked to stand with his/her feet still, fixed in one place. "Follow this object as Imove it. Keep watching it as Imove it, but don't move your feet." **EQUIPMENT**: a brightly colored object of at least two inches in size, or flash cards, a twelve inch long masking tape line or two footprints placed shoulder width apart

- ○ 4 looks behind/over each shoulder; weight shifts include trunk rotation
- ○ 3 looks behind/over one shoulder with trunk rotation; weight shift in the opposite direction is to the level of the shoulder; no trunk rotation
- ○ 2 turns head to look to level of shoulder; no trunk rotation
- ○ 1 needs supervision (spotting) when turning; the chin rnoves greater than half the distance to the shoulder
- ○ 0 needs assist to keep from losing balance or falling; movement of the chin is less than half the distance to the shoulder

12. Pick Up Object From The Floor From A Standing Position

INSTRUCTIONS: The child is asked to pick up a chalkboard eraser placed approximately the length of his/her foot in front of his/her dominant foot. In children, where dominance is not clear, ask the child which hand they want to use and place the object in front of that foot.
EQUIPMENT: a chalkboard eraser, a taped line or footprints

- ○ 4 able to pick up an eraser safely and easily
- ○ 3 able to pick up eraser but needs supervision (spotting)
- ○ 2 unable to pick up eraser but reaches 1 to 2 inches from eraser and keeps balance independently
- ○ 1 unable to pick up eraser; needs supervision (spotting) while attempting
- ○ 0 unable to try, needs assist to keep from losing balance or falling.

13. Placing Alternate Foot On Step Stool While Standing Unsupported

INSTRUCTIONS: The child is asked to place each foot alternately on the step stool and to continue until each foot has touched the step/stool four times.

EQUIPMENT: a step/stool of four inches in height, a stop watch or watch with a second hand

- ○ 4 stands independently and safely and completes 8 steps in 20 seconds
- ○ 3 able to stand independently and complete 8 steps >20 seconds
- ○ 2 able to complete 4 steps without assistance, but requires close supervision (spotting)
- ○ 1 able to complete 2 steps; needs minimal assistance
- ○ 0 needs assistance to maintain balance or keep from falling, unable to try

________ Time in seconds

14. Reaching Forward With Outstretched Arm While Standing

General Instruction and Set Up: A yardstick affixed to a wall via Velcro strips will be used as the measuring tool. A taped line and/or footprints are used to maintain a stationary foot position. The child will be asked to reach as far forward without falling, and without stepping over the line. The MCP joint of the child's fisted hand will be used as the anatomical reference point for measurements. Assistance may be given to initially position the child's arm at 90 degrees. Support may not be provided during the reaching process. If 90 degrees of shoulder flexion cannot be obtained, then this item should be omitted.

INSTRUCTIONS: The child is asked to lift his/her arm up like this. "Stretch out your fingers, make a fist, and reach forward as far as you can without moving your feet."

EQUIPMENT: a yardstick or ruler, a taped line or footprints a level,

3 Trials Average Results

- ○ 4 can reach forward confidently >10 inches
- ○ 3 can reach forward >5 inches, safely
- ○ 2 can reach forward >2 inches, safely
- ○ 1 reaches forward but needs supervision (spotting)
- ○ 0 loses balance while trying, requires external support

______ Total Test Score

Maximum Score = 56

Appendix #4: Six-Minute Walk Test

The following elements should be present on the 6MWT worksheet and report:

Lap counter:__ __ __ __ ____ __ __ __ ____ __ __ __ __

Patient name: ____________________Patient ID# ___________

Walk # ______Tech ID: _________ Date: __________

Gender: M FAge: ____Race: ____Height: ___ft ____in, ____ meters

Weight: ______ lbs, _____kgBlood pressure: _____ / _____

Medications taken before the test (dose and time): __________________

Supplemental oxygen during the test: NoYes, flow ______ L/min, type _____

	Baseline	End of Test
Time	___:___	___:___
Heart Rate	_____	_____
Dyspnea	____	____ (Borg scale)
Fatigue	____	____ (Borg scale)
SpO_2	____ %	____%

Stopped or paused before 6 minutes? NoYes, reason: _______________

Other symptoms at end of exercise: angina dizziness hip, leg, or calf pain

Number of laps: ____ (60 meters) final partial lap: _____ meters

Total distance walked in 6 minutes: ______ meters Predicted distance: _____ meters Percent predicted: _____% Tech comments:

Interpretation (including comparison with a preintervention 6MWD):

Appendix #5: Consent Form to Participate in the Study

نموذج الموافقة على المشاركة في البحث

اسم البحث : تأثير برنامج تمارين مقترح على التوازن واللياقة القلبية الوعائية لدى الأطفال المصابين بمتلازمة داون

اسم الباحثة : رزان هلال

عزيزي الأب –الأم - الشخص المسوؤل

تهديكم الباحثة في هذه الدراسة اطيب الأمنيات وتشكر لكم استعدادكم لمشاركه ابنكم او ابنتكم بهذا البحث، الذي هو جزء من دراسة الماجستير في العلاج الطبيعي من جامعة القدس

توقيعك ادناه على نموذج الموافقة هذا هو بموجب موافقة مكتوبة وموقعة على مشاركه ابنك - ابنتكم في دهذه الدراسة

و هو إقرار بإنه قد تم شرح أهداف البحث و طريقة الفحص و وتطبيق ادوات القياس للبحث ، وانه قد تم شرح حقوقك المتضمنة:

- سرية المعلومات التي تصرح بها وعدم إطلاع اي شخص عليها و تخزينها في مكان امن لا يصل اليه سوى الباحث.
- إخفاء هوية المشارك في تحليل البحث والنتائج.
- استخدام المعلومات للاغراض العلمية فقط.
- حرية إنسحابك في اي وقت من الدراسة ومن دون الحاجة لإبداء الأسباب ودون اية عواقب شخصية او مالية.
- حقك في الإطلاع على نتيجة فحوصاتك ونتائج البحث النهائية.

وأنه في حال كان لديك أسئلة حول الدراسة او حول اي معلومة متعلقة بها, يرجى الاتصال بالباحثة رزان هلال على *رقم التلفون*: 0598031541

موافقة المشارك

لقد تم وصف الدراسة البحثية لي شفهيا، وبما فيه المعلومات المدرجة أعلاه، وأوافق على المشاركة بهذه الدراسة البحثية. سوف أحصل على نسخة موقعة من هذا النموذج للاحتفاظ بها في سجلاتي، أوافق على المشاركة بهذة الدراسة.

اسم الابن –:

اسم الوالد او الوالدة:

توقيع الوالد او الوالدة أو الشخص المسوؤل :

تأثير برنامج تمارين مقترح على التوازن واللياقة القلبية الوعائية لدى الأطفال المصابين بمتلازمة داون

إعداد: رزان ميشيل هلال

إشراف: د. هديل حلاوة

الملخص

الخلفية: متلازمة داون، أو التثلث الصبغي 21، هو اضطراب وراثي ناتج عن وجود نسخة إضافية من الكروموسوم 21، ويؤدي إلى إعاقات جسدية وعقلية، وملامح وجه نمطية، وتأخر النمو، وانخفاض التوتر العضلي. وأفراد متلازمة داون عرضة للمضاعفات الطبية مثل: أمراض القلب، والسمنة، ومرض السكري.

الهدف: تقييم فعالية برنامج تمارين منظم يدمج التمارين الهوائية وتمارين التوازن، لتحسين اللياقة القلبية الوعائية والتوازن لدى أطفال متلازمة داون.

الطريقة: أُجريت دراسة مقارنة (أحادية التعمية) على 40 طفلاً من متلازمة داون تتراوح أعمارهم بين 4 و12 عاماً من مركزي يميمه وبوابة الحياة في بيت جالا، تم توزيعهم وفقاً للعينة المتاحة، على مجموعتين: تجريبية، شاركت في برنامج تمارين منظم لمدة جلستين أسبوعياً، مدة كل منهما 60 دقيقة، على مدى 12 أسبوعاً. وضابطة تلقت جلسات علاج طبيعي قياسية. وقد تم تقييم التوازن واللياقة القلبية الوعائية باستخدام اختبار توازن بيرج واختبار المشي لمدة 6 دقائق القبلي والبعدي.

النتائج: أشارت نتائج الدراسة إلى أن برنامج التمارين الرياضية المُقترح قد حقق تحسناً ملحوظاً في كل من القدرة على التحمل القلبي الوعائي والتوازن لدى الأطفال المصابين بمتلازمة داون. حيث أظهر المشاركون في مجموعة التدخل (التجريبية) زيادةً ذات دلالة إحصائية (0.001)، في أداء اختبار المشي لمدة (6) دقائق وحجم تأثير كبير جداً (3.433)، إلى جانب التحسن الملحوظ في التوازن العام عبر قياسه بواسطة مقياس بيرج للتوازن بدلالة إحصائية (0.001)، وحجم تأثير (1.447) مقارنةً بالمجموعة الضابطة. كما أن مجموعة التدخل أظهرت تحسناً كبيراً في مهام توازن محددة، بما في ذلك أنشطة أكثر تحدياً مثل الدوران 360 درجة والوقوف على قدم واحدة بدلالة إحصائية (0.001). علاوة على ذلك، لوحظ وجود علاقة إيجابية قوية بين القدرة على التحمل القلبي الوعائي وأداء التوازن بعد الاختبار بدلالة إحصائية (0.001) وقيمة ارتباط (0.663).

الاستنتاج: تستنتج الدراسة أن تدخلات النشاط البدني المُستهدف قد تلعب دوراً حاسماً في تعزيز الوظيفة الحركية العامة واللياقة البدنية لدى أطفال متلازمة داون.

الكلمات المفتاحية: متلازمة داون، برنامج تمارين مقترح، لياقة القلب والأوعية الدموية، التوازن.