PREDICTING DYNAMIC BALANCE AND MOBILITY IN CHILDREN WITH DOWN SYNDROME USING MACHINE LEARNING AND LOWER LIMB FITNESS PROGRAMS

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ABSTRACT: Lower Limb Fitness Program was one of the core muscle and lower extremity muscle strengthening exercises that aim to improve lower extremity muscle power to prepare foot muscle in the standing process to compare the effects of Lower Limb Fitness Program with Routine Physical Therapy. About 28 patients with Down syndrome were screened for eligibility according to inclusion, exclusion criteria. Informed consent was obtained from eligible participants. Based on inclusion and exclusion criteria. By using lottery method participants were distributed into 2-groups i.e. Group-A which is Experimental group and Group-B that is Controlled group. In group-A Lower Limb Fitness Program which involved Range of motions to both sides, Proprioceptive training and Squats to stand training for lower limb were performed. In group B In control group routine therapy strengthening exercises. Dynamic balance and mobility were evaluated by using Pediatric balance scale, Time up and go test and CTSIB at baseline and at the end of post session of treatment. Data was analyzed using SPSS version 25.0 to find outcomes. Mean age of children which was 8.2500± 1.81812 years. Outcomes showed that both groups improved significantly after therapy (P<0.05). Lower Limb Fitness Program significant potential for improving dynamic balance and mobility in kids with Down syndrome. So, research conducted that group who received Lower Limb fitness Program along with Routine therapy showed more improvement in outcome measures like PBS, TUG and CTSIB as compared to the group who received Routine therapy Exercises.

Keywords- Down syndrome, Lower Limb Fitness Program, Dynamic Balance, Mobility

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INTRODUCTION

Down syndrome is a chromosomal abnormality that was present at birth Down syndrome or Down's syndrome, also known as trisomy 21, is a genetic disorder caused by the presence of all or part of a third copy of chromosome 21. It is usually associated with developmental delays, mild to moderate intellectual disability, and characteristic physical features (1, 2). Arising when associated to children without disabilities, children with Down syndrome grow differently, with their body height being 2 to 3 cm shorter. In most cases, there was no growth hormone shortage to account for the slowed growth. Along with diminished physical strength and cardiovascular capacity, those with Down syndrome also had trouble sleeping and performed poorly when walking (3).

The most common cause of Down syndrome was a cell division defect known as "nondisjunction". It is estimated that the prevalence of live births worldwide is 0.1% (4). Due to developments in medicine and interdisciplinary care, which includes appropriate physical activity regimens, persons with DS now live longer. People who have Down syndrome (DS) display physical characteristics and impairments associated with cognitive abilities, facial structures, hyperlaxity, hypotonia, and other changes. They might be lacking in gross motor skill development, which is associated with poor muscle tone and ligamentous hyperlaxity. Delays in learning motor patterns and the emergence of abnormal patterns are caused by DS (5).

Neuromuscular abnormalities in children with Down syndrome (DS) cause them to miss developmental milestones, move poorly, and have poor balance (6). Compared to children with other mental disabilities, children with DS also score lower on tasks involving balance, agility, strength, and visual-motor skills. These issues could be caused by a tiny cerebellum and brainstem, as well as delayed cerebellar maturation (7).

Although the exact reasons for their inferior fitness are unknown, their low peak heart rate (about 30% below predicted) may be the result of decreased physical activity, respiratory issues, or weaker muscles. In addition to having a higher risk of obesity, diabetes, osteoporosis, and cardiovascular disease, people with Down syndrome are also more likely to experience an early and substantial loss in function as they age. It is also a relevant time since their physical capabilities may be a determining factor in future work (8, 9).

One of the most significant motor deficits in people with Down syndrome is an atypical walking pattern (10). Compared to those without Down syndrome and even those with other difficulties, those with Down syndrome engage in less physical exercise. The lack of exercises can cause health problems, impaired motor development, and decreased social interaction (11). Children's growth and development are vital aspects of their life. Since every child has unique characteristics during each stage of growth and development, issues at one period will inevitably impact subsequent stages of life. Sadly, not every child experiences normal growth and development, and as a result, some will require particular care at this time (12).

Children with Down syndrome are more prone to falls because they have trouble maintaining good body alignment and have abnormal walking patterns (13). To enhance motor function impairments, neuromuscular training has been established. The term "neuromuscular training" refers to the stimulation obtained from physical workouts with the goal of improving several neuromuscular aspects such as muscular strength, physical coordination, and functional motions (14).

It's been said that when DS patients have hypotenuse muscles, their quality of life may be low. It has been documented that the hypotenuse muscular nature of Down syndrome individuals significantly impacts their academic performance and self-care abilities (1). In healthy children, regular exercise and training regimens enhance body composition (15). An increased risk of falling is linked to lower limb muscle weakness and poor standing balance. Numerous studies have shown that walking training regimens improve older people's muscle strength, endurance, and balance (16).

Children's diagnosed with Down syndrome (DS) may exhibit increased postural sway and delayed motor development. It is hypothesized that muscle weakness and hypotonic especially in the lower extremities, will affect their general physical well-being and capacity to carry out everyday tasks (17). Children with DS frequently have problems with their posture, balance, and mobility (18).Weakness in their muscles might also affect their capacity to carry out daily tasks, such as walking. Strengthening has been linked to improvements in people with intellectual disabilities' work-related skills and in functioning activities for people with DS (8).

Children diagnosed with Down syndrome experience delays in postural control and movement due to challenges with balance, equilibrium, and protective reactions. An increase in balance can lead to increased stability when carrying out regular tasks or jobs involving the workplace. When it comes to helping children with disabilities with their movement issues and balance deficiencies, traditional physical therapy methods are repetitive and don't do much to help young patients stay focused throughout lengthy treatment sessions. Apart from this, children with Down syndrome often exhibit challenges while practicing functional activities repeatedly due to their physical constraints and cognitive impairments, as well as the unpredictability of the intervention setting (19).

Individuals with Down syndrome (DS) typically exhibit impaired motor proficiency (balance and postural control), physical functional limits, and reduced physical fitness (aerobic capacity, muscle strength, and aberrant body composition). In addition to increasing exercise compliance and engagement, games can also improve motor function and physical fitness (20). DS frequently exhibit more postural sway, which causes a noticeably higher deviating center of pressure (21).

Children and adolescents with Down syndrome might benefit from therapeutic physiotherapy interventions that support the development of motor skills and enhance functional performance using therapeutic exercise, among other intervention possibilities, to stimulate mobility and independence in everyday accomplishments. Applying physical exercise parameters, such as intensity, frequency, and duration, for therapeutic purposes is known as therapeutic exercise (12, 22). In order to increase muscle strength in children with Down syndrome, exercise is essential. highlighting their robust muscles and physical well-being (23).

Exercises for core stability have a positive effect on lumbar spine stability, abdominal muscle activation, pain alleviation, and performance. Moreover, the stability of the core region can lessen anomalies and damage to the muscles, coordinate the muscles of the upper and lower trunk, and enhance dynamic balance. Physiotherapy played a part in helping children with Down syndrome receive training. One such exercise that they used was squat to stand exercise, which appeared to increase lower extremity muscle authority. Training from squat to stand will increase proprioceptive activation in the lower extremities and trunk. The leg muscles will be highly stimulated throughout the squat-to-stand movement, which will have a substantial effect on the body's stability in the balanced position (24).

The diaphragm muscle forms the box's roof, the pelvic girdle muscles make the floor, and the muscles of the spine and gluteal region constitute the posterior half of the core stability area. The lumbar vertebrae are the site of the central stability muscular system, which maintains the spine throughout its range of motion. Additionally, the physiological functions of the trunk muscles and ligaments aid in maintaining bodily stability and control. The muscles of the thighs, abdomen, and lower back work in perfect unison to produce power for dynamic balance (25).

Additionally, having better balance and gross motor abilities would help them participate more fully in daily activities and feel better about themselves (26). Moving programs also helped children with Down syndrome maintain better balance, according to the findings of other research looking at the impact of exercise regimens on children's balance (27). Exercises for core stability can help patients feel less discomfort, engage their deep abdominal muscles, increase the strength of their lumbar spine, and have better physical function (28, 29).

Numerous exercise interventions can help children with Down syndrome become more balanced, stronger, and more coordinated in their gross motor skills. These exercises consist of general physical activities, muscle strength exercises, balance exercises, and combinations of these therapies. Pilates exercises involve movements that engage the neuromuscular components of the balance system, which are essential for preserving the body's stability. They also alter the body's balance both structurally and functionally (30).

Children with DS showed notable gains in their dynamic balance when they participated in a combined regimen of treadmill training and core stability exercises (31). Programs for the lower limbs also enhance mobility. Children with Down syndrome are better able to move about their environment because they have stronger leg muscles and improved balance. The ability of physical exercise regimens to enhance everyday life abilities and functional mobility in kids with Down syndrome (32).

Therapeutic programs and interventions focused on physical activity training, like postural balance and isokinetic muscular strength training, can help improve postural control. While improvements in ambulation and gait, joint mobility of the lower extremities, and motor function are all facilitated by treadmill training and customized low- and high-intensity training, the effects on individuals with Down syndrome are less pronounced than in the general population(33).

The capacity to sustain, attain, and regain equilibrium in whatever position that is adopted was known as postural control. But its purpose is not limited to posture maintenance; it also serves as a means of movement, safe performance of daily tasks, and reaction to outside disturbances (34).

Currently, a range of physical treatment methods, like aquatic therapy, and isokinetic strength training, are being used to help children with DS increase their lower limb muscular strength and postural stability. Stretch-shortening exercises, also called plyometric exercises, are a type of resistance training that is commonly used in resistance training programs. In these exercises, the muscle contracts in three phases during dynamic movements, such as jumping and hopping, moving quickly through the eccentric, isometric, and concentric phases. Children with neurodevelopmental issues have found that the stretch-shortening exercises are an effective way to improve their muscle strength, muscle coordination, and response capacity to balance risks (35).

Down syndrome, variations in the impact of high and low dynamic body balance on the children's motor skills and endurance of their core muscles, and the connection between games and actively body balance (high and low) on the children's development of these skills (36).

Exercise (mixed programs, aerobic training, progressive resistance training, balance training) seems to benefit people with Down syndrome in ways that are comparable to those of the general public. Exercise can increase muscular strength, cardiovascular fitness, and decrease activity restrictions as long as physiotherapists follow the suggested standards (i.e., appropriate dose and intensity) (37).

When impaired fine and gross motor skills. Studies reveal that people with Down syndrome develop their muscles at a slower rate than people without the condition (38). The inability to execute actions of daily existing, such as ambulatory, working, climbing stairs, or getting up and sitting on a chair, is directly impacted by lower extremity weakness (39). Swimming is an aerobic exercise that works a lot of the large muscle groups and may be more beneficial for functional fitness (40).

Additional issues with balance responding include insufficient co-contraction brought on by mental retardation, muscle weakness, abnormalities in the integration of sensory information, cartilage hypoplasia, and insufficient bone density (41). After the ages of nine or ten, several components of postural control still seem to be developing (42). Both healthy people and those with Down syndrome (DS) may be more at risk of falling due to body unevenness and reduced postural control, which can negatively affect walking. Given that those who have DS have lower physical levels than those who have not (43). With this knowledge, rehabilitation programs might be created to improve dynamic postural control in this population, increasing their engagement in day-to-day activities (44).

Both treadmill training and core stability exercises are important components of physical therapy interventions and have an impact on children with Down syndrome (DS) in terms of balance; however, it is yet unknown which of the two has a greater impact on improving balance (45). For most human tasks, maintaining equilibrium is a subordinate but necessary prerequisite. The majority of children with Down syndrome (DS), who make up a sizable population in our society, have deficiencies in balance, coordination, and gait both during childhood and maturity. In order to assist in resolving such a pervasive issue, it is imperative to look for the best physical therapy program (46).

Because the capacity to maintain body balance is correlated with lower-limb strength, exercise programs that target ankle strength have been shown to improve participants' standing balance. It is essential to have balance and postural control in order to perform daily motor tasks and motions in a safe manner. Therefore, for this population, these postural and balance deficiencies pose a significant functional constraint (47).

It is critical to keep presenting new data demonstrating the advantages of resistance training for individuals with Down syndrome. This would yield more data that would be particular to the prescription of exercise for this population of people with this genetic condition and contribute to future guidelines. The existing body of exercise physiology literature mostly focuses on the physical strength increases and general physical activity levels that result from aerobic exercise in individuals with Down syndrome. There was no doubt that aerobic exercise was extremely beneficial for people with Down syndrome based on this line of study (48).

Children with Down syndrome often exhibit challenges with muscle tone, strength and balance. A well-designed lower limb fitness program can address these challenges and lead to several benefits.

LITERATURE REVIEW

Abinaya K et.al was investigated this study in 2024 to evaluate the benefits of strengthening and aerobic activities for people with Down syndrome. Groups A and B were created at random from twenty patients with Down syndrome. Ten subjects in group A received aerobic exercise, whereas ten subjects in group B received strengthening exercises. As an outcome measure, the Dynamic Gait Index Scale was used, and it was pre-assessed on Day 1. Each group received treatment for four weeks, with two sessions per day, and a post-assessment of the outcome measures in between. After statistical analysis of the research's data, it was shown that increasing exercise had a demonstrable beneficial impact on the functional mobility of people with Down syndrome (49).

This study was investigated by Heidari, Ghasemi, Sadeghi, Ghasemi, & Kahrizsangi in 2024 sought to determine how eight weeks of combined turning exercises affected the academic performance of female students with Down syndrome who were able to learn. The authors employed selective sampling in this semi-experimental clinical investigation to register 26 female students who had been diagnosed with Down syndrome. For eight weeks, the experimental group participated in three sessions of combined turning training, lasting 45–60 minutes each day. People with DS may do better physically and have a higher quality of life overall (40).

H. Takahashi et.al was investigated this study in 2023 to determine the efficiency of group dance movement therapy for people with Down syndrome. Thirty-one DS participants, ages five to nineteen, were split into two groups at random: the intervention group (n = sixteen) and the control group (n = fifteen). Static balance was measured by post urography, dynamic balance was measured using the timed up and go test and adaptive function and behavioral problems were measured in individuals before and after the dance movement therapy therapies using the Achenbach System of Empirically Based Assessment questionnaire. The control group carried out their regular daily activities, while the intervention group received ten weekly 60-minute DMT interventions. This study demonstrated how dance movement therapy therapies enhanced the dynamic balance in DS patients (50).

Yelda Kaya et.al was investigated this study in 2023. This study sought to ascertain how hippocampal therapy affected children with Down syndrome in terms of balance, functional mobility, and functional independence. Following the first evaluation, thirty-four DS children were randomized at random to the experimental (hippotherapy) and control groups. In addition to physiotherapy, which included balance exercises for both groups, the experimental group also got hippocampal hippotherapy as an additional integrative therapy. Prior to and following the intervention, the Pediatric Balance Scale (PBS), Timed Up and Go Test (TUG), and Functional Independence Measure for Children were administered. Therefore, it will be more successful to increase the functional independence of children with Down syndrome by offering hippocampal treatment as an adjunctive therapy to physiotherapy (51).

This study was conducted by Michaels et.al in 2023 to determine the efficiency of swimming exercise in enhancing balance in people with Down syndrome. The second edition of the Pediatric Balance Scale (PBS-2) was used to examine five DS participants, and their parents filled out the Activities-definite Balance Confidence gauge. After that, for six weeks, they took part in an aquatic exercise intervention twice a week. The PBS-2 and the Activities-specific Balance confidence scale were used to examine the subjects once more after the 6-week intervention. The results of this small feasibility study support the practicality of aquatic exercise to improve balance for children and young adults with DS (52).

Rameel ur Rehman Cheema et.al investigated a study in 2023 to determine the impact of retro-walking and core stability activites on balance and coordination in individuals with Down syndrome. 24 individuals with mild to severe mental retardation who were between the ages of 8 and 14 and had a verified diagnosis of DS participated in this randomized clinical trial. They were divided into two groups: Group B underwent retro walking for eight weeks, and Group A received core stability exercises. Children with DS showed considerable improvements in balance and coordination with core stability training and retro walking (53).

Habiibatusy Syaahidah et.al investigated a study in 2022 to determine the impact of squat-to-stand instruction on a patient with Down syndrome. This is a single-subject study on a 19-month-old Down syndrome youngster who has a walking delay. For four weeks, the patient had twice-weekly squat-to-stand training with a follow-up at the conclusion of each session. After four weeks of intervention, there is an improvement in the muscle tone and movement. The XOTR examination showed improvement, with the baseline result being T, which was interpreted as the existence of muscle contraction with minimal movement (24).

Adelia Rahmayanti et.al investigated this study in 2022 to determine the impact of combining lower extremity strength and core stability activities on children with Down syndrome's ability to balance while standing in a static position. In order to enhance the subject's ability to balance while standing still, this study employs a single subject approach. The youngster, who has been diagnosed with Down syndrome, receives four weeks of lower extremity strength training and core stability exercises. The Gross Motor Function Measure was used in this study to assess the participants' ability to balance while standing still. Measurements were obtained prior to the exercise (A1), during the follow-up (B), and during the final assessment (A2). It is thought that twice a week, lower extremity strength and core stability exercises will not help children with Down syndrome become more adept at static standing balance (54).

This study discovered by Yun-A Shin et.al in 2021 to evaluate the effects of resistance training and balance on physical functions and postural control in children with Down syndrome. The experimental group involved of 10 participants with Down syndrome who take part in 8-week balance and resistance training program. The control group which involved10 individuals who did not receive any physical training. Three times a week, for eight weeks, 60 minutes each was enthusiastic to resistance and balance training. The physical fitness of the experimental and control groups significantly increased as indicated by the number of sit to stand repetitions and 10 meter shuttle’s length. These results suggested that addressing the musculoskeletal problems through resistance and balance training was a helpful strategy to help those persons who suffer with Down syndrome prevent from injuries, falls and fatigue during exercises (55).

This study Evaluated by Anggi Setia Lengkana et.al in 2020 concluded the effects of static and dynamic balance in schools. A pretest and posttest control group design were used in conjunction with an experimental random sampling approach. The sample consists of elementary school pupils of grade 5 and 6. The instruments were used as tests include the standing crane test and the star balance Excursion balance test. The results showed that balance education, weather static or dynamic had a significant impact on the development of balance in elementary school pupils (56).

This research explored by Alsakhawi & Elshafey in 2019. The aim this study was to find out how treadmill workouts and core stability training affected the balance of kids with Down syndrome. Three equal groups were randomly selected from among the children. To help the participating children maintain their balance, Group A was given typical physical therapy intervention techniques. Group B had the same treatment as group-A plus extra instruction in core stability exercises. Group C underwent a treadmill exercise program in addition to receiving the same intervention measures as group A. The Berg balance scale and the Biodex balance system were used to assess the children's balance. For eight weeks in a row, there were three weekly sessions lasting sixty minutes each. Core stability and treadmill training improved balance in children with Down Syndrome and should be applied in conjunction with physical therapy programs (57).

M Ortiz-Ortiz was investigated this study in 2019 to determine the impact of a physical exercise regimen on children with Down syndrome's isometric strength and body composition. Physical exercises regimen on isometric strength and body composition in kids with Down syndrome. Nine children in the control group and thirteen in the experimental group were the twenty-two children with DS. Measurements were taken of the medial calf skinfolds, body height, weight, triceps, and isometric handgrip strength. Body height and weight were used to calculate the body mass index, or BMI. The 16-week physical fitness program was completed in five weekly sessions lasting 55 minutes each. Participants with Down syndrome saw improvements in their body composition and isometric strength after completing a workout program. Organized physical fitness training can enhance the quality of life for children diagnosed with Down syndrome (58).

This study was investigated by Amadeusz Skiba et.al in 2018. The aim of this study was to determine the impact of physical training and Nordic Walking on adult individuals with Down syndrome's body composition and balance. Thirty-two participants with mild intellectual disability who suffered with Down syndrome. Three groups were randomly assigned to them: one for physical training, one for Nordic walking training, and one for no intervention control. Three times a week for ten weeks, there were training sessions. A week prior to training and a week following the intervention, the subjects underwent examinations twice. Study indicates that persons with Down syndrome assistance from regular physical activity for example Nordic Walking training in terms of their balance (59).

In 2017, Eid et al. conducted an investigation on this work. This study examined the effects of isokinetic training on children with Down syndrome's postural balance and muscle strength. 11 Down syndrome children were, ranging in age from 9 to 12, were arbitrarily assigned to two groups. For a period of twelve weeks, the experimental group received isokinetic training three days. According to the findings, kids with DS who took part in the isokinetic training program improved more in terms of their muscle strength and postural balance. (17).

S. Bahiraei et al. looked into the previous study in 2017. This study sought to determine the effects of a selective combination training program on the motor skills, balance, and muscle strength of boys with Down syndrome. Twenty boys with Down syndrome, ranging in age from 12 to 20, were accidentely assigned. The experimental group's paricipants underwent a combined training regimen. Children with Down syndrome benefit from proprioceptive and muscular training together to enhance their postural balance (60).

The previous study was investigated by Jung, Chung, & Lee in 2017. The aim of this study was to calculate the differences in age-appropriate gait and balance between children with Down syndrome and typically developing kids. Twenty children's with typical development and sixteen children with Down syndrome served as the subjects. The gait and balance of the children were assessed using the one-leg standing test, GAITRite, sharpened Romberg's (open eyes/closed eyes), functional reaching test, and Romberg's test. The findings imply that whereas normally growing children's balance and gait abilities increase with age, those of Down syndrome children stay low even with independent movement (61).

This study investigated by Sobhy M. Aly and Asmaa A. Abonour in 2016. This study looked into how core stability exercises affected the postural stability of kids. 30 kids with Down syndrome, ages ranging from six to ten, participated in this study (21 boys and 9 girls). They were divided into study and control groups at random. While the control group underwent conventional physical treatment, the study group participated in core stability exercises and received traditional physical therapy. The course of treatment lasted for eight weeks. The Biodex Balance System was used to assess postural strength both before and after therapy. Children with Down syndrome can improve their postural stability and balance with eight weeks of core stability exercises. Exercises for core stability have to be a significant component of a child with Down syndrome's rehabilitation regimen (28).

A lot of studies focus on general exercise program or combine lower limb exercises with other interventions. Therefore, this clinical study was conducted to fill the literature gap on the possessions of this topic.

DATA COLLECTION PROCEDURE

- **Recruitment:** Participants were referred by: Autism, special needs and developmental disorders clinic, Lahore.

- **Screening:** All the referred participants were assessed for the eligibility criteria for screening balance by using a tool Pediatric Balance scale: score less than 50 on the pediatric balance scale indicating adequate balance function. Guardians of participants accomplishing the appropriateness measures were asked to sign the consent forms before inflowing them to the study.

- **Allocation:** The subjects who met the inclusion/exclusion criteria were allocated for the study.

- **Randomization**: Computerized method of randomization used to randomize screened eligible patients to Group A and Group B. G Power used for this purpose, which is an open-source free software for online minimization and randomization for clinical trials.

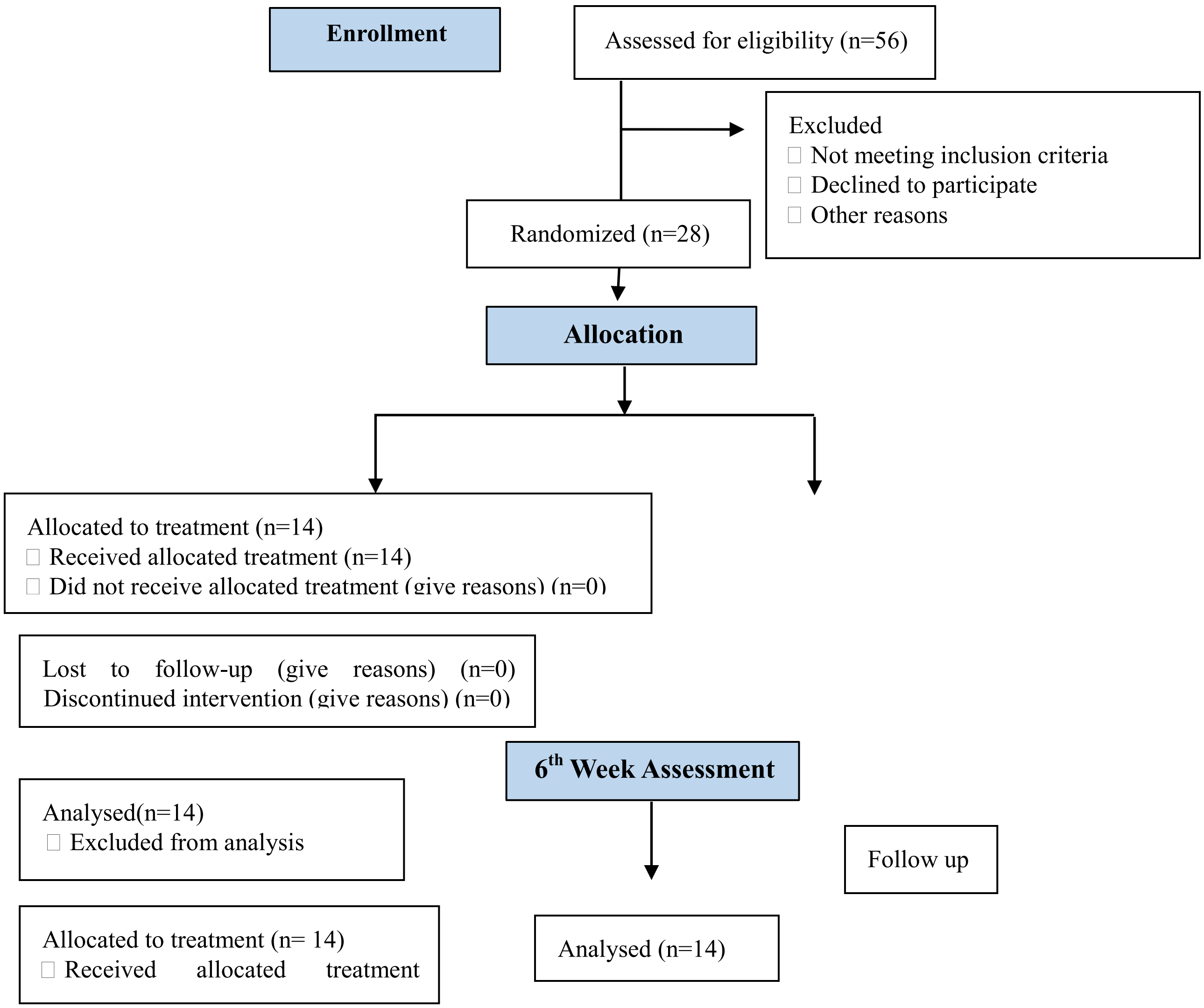
- **Blindness:** This was single blinded study in which only assessors may be masked from treatment options of two groups.

- **Intervention:**

Experimental Group: Group A was received ROM's for 5 minutes involved activities that stretch and reinforce the muscles and increase the stability. 5 minutes of proprioceptive training that include single leg balance that increase each leg's duration gradually from 20 to 30 seconds to 1 min. and 2 to 3 sets. For 5-10 minutes per session, perform weight bearing exercise on an uneven surface such as stability disc or Bosu ball and jumping rope. Every proprioceptive training performed with the eyes at first subsequently closed (10, 21). Lower extremity training using squat to stand exercises. The purpose of this intervention was to enhance proprioceptive ability and prepare the muscles for the actual intervention. For six weeks, the exercises were performed three times a week for 45 minutes each. The exercises included squat-to-stand training, which was repeated 30 times in three sets of 20 minutes each. One set followed by a two-minute rest. For ten minutes per session, balance training entails standing exercises with support before moving on to unsupported activities as tolerated. (22). for six weeks, routine therapy was administered three times a week for forty five minutes each. Exercises included standing balance, sitting from chair to standing position and standing from knee to toe position.

Control Group: The control group received normal PT three times a week for six weeks, including 45-minute sessions that included standing balancing exercises, sitting from a chair to a standing position, and a heal-to-toe stand.

CONSORT Diagram:



RESULTS

Twenty-eight individuals with Down syndrome were randomly assigned to one of two groups in an experimental investigation. To find out how the Lower Limb Fitness Program affected the dynamic balance and mobility of children with Down syndrome, 14 individuals were placed in group A (the Lower Limb Fitness Program) and 14 subjects were placed in group B (the Routine Therapy group). Children's gender distribution: 13 (46.4%) were female and 15 (53.6%) were male. The children's average age was 8.2500± 1.81812 years. Children with Down syndrome had a minimum age of six and a maximum age of twelve. Paired and independent test ’t’ tests were used to determine whether they were significant difference in the magnitude of effect of lower limb Fitness Program. Paired ‘t 'test used to translate results within the group and independent ‘t’ tests used to perform describe the results between groups. Inter group analysis of Pediatric balance scale of group A and B. Results showed the mean value of Pre test PBS score for Lower Limb Fitness Program (Group A) as 32.50 and standard deviation of 4.48 and for Routine Therapy (Group B) mean value was 35.21 and standard deviation of 5.83. The post test PBS mean value for Group A was 41.42 which was greater than the post test PBS mean value for Group B 38.21. P value is less than 0.05 that indicate significant results. Within group analysis of TUG test. Results indicated TUG score for Lower Limb Fitness Program (Group A) as 13.57and standard deviation of 1.65084and for Routine Therapy (Group B) mean value was 13.92 and standard deviation of 1.384.

The post test TUG mean value for Group A was 9.97 which was less than the post test TUG mean value for Group B 11.87. P value is greater than 0.05 that indicate results were not significant.

Before test CTSIB score for Lower Limb Fitness Program (Group A) as 78.21 and standard deviation of 17.38 and for Routine Therapy (Group B) mean value was 93.92 and standard deviation of 17.38. The post test CTSIB mean value for Group A was 140.35 which was greater than the post test CTSIB mean value for Group B 93.92. P value is equal to 0.05 that indicate results were significant.

Results showed within groups Paired "T" test was performed that the mean value of pre-test of 32.50 and post- tests of 41.42 and standard deviation 4.48 and 3.17 respectively of PBS in group A. Inter group investigation of group B for PBS results presented that the mean value of pre-test of 8.28 and post- test of 1.50 and standard deviation 1.81 and 0.51 respectively of PBS in group B. P value of Group A was less than 0.05 which indicates the results were more significant as compared to Group B.

Results showed within group that the mean value of pre-test of 13.57 and post- test of 9.92 and standard deviation 1.65 and 1.20 respectively of TUG in group A. Within group exploration of group B for PBS results showed that the mean value of pre-test of 35.21 and post- test of 37.78 and standard deviation 5.83 and 5.55 respectively of TUG in group B.

Table 1 Gender Distribution

Gender	Frequency	Percentage
Male	15	53.6
Female	13	46.4
Total	28	100.0

Results showed within group that the mean value of pre-test of 78.21 and post- test of 140.35 and standard deviation 17.38 and 13.07 respectively of CTSIB in group A. Within group exploration of group B for CTSIB results showed that the mean value of pre-test of 13.92 and post- tests of 11.85 and standard deviation 1.38 and 1.29 respectively of PBS in group B. P value of post treatment of group 1 experiment group was less than 0.05 was highly significant.

The above table represents the gender distributions of patients, off which 15 (53.6%) were boys while 13 (46.4%) were girls.

Table 2 Distribution of Age

Mean	8.2500
Standard Deviation	1.81812
Minimum	6
Maximum	12

The average age of the kids were 8.2500± 1.81812 years, as seen in the above table. Children with Down syndrome had a minimum age of six and a maximum age of twelve.

Table 3 Normality test

Shapiro-Wilks Normality Test

Variables	Statistic	Df	Sig.
Pre PBS	.947	28	.165
Post PBS	.950	28	.194
Pre TUG	.915	28	.126
Post TUG	.956	28	.275
Pre CTSIB	.957	28	.294
Post CTSIB	.977	28	.768

Test scores were obtained before and after 6-week intervention. Normality test (Normality test such as Shapiro-wilks) was performed to check the data was normally distributed so parametric test like paired and independent test 't' tests were used to determine whether they were significant difference in the magnitude of effect of lower limb Fitness Program. Paired 't 'test used to translate results within the group and independent 't' tests used to perform describe the results between groups.

Independent T test between for Pediatric Balance Scale

Table 4 between groups Analysis for PBS Independent T test

Outcome Measure	N	Treatment Groups				T values	P Value
		Group A		Group B			
		Mean	SD	Mean	SD		
PBS Before treatment	28	32.50	4.48	35.21	5.83	-1.380	0.248
PBS After treatment		41.42	3.17	38.21	5.42	1.913	0.041

Results explored the mean value of Pre test PBS score for Lower Limb Fitness Program (Group A) as 32.50 and standard deviation of 4.48 and for Routine Therapy (Group B) mean value was 35.21 and standard deviation of 5.83 The post test PBS mean value for Group A was 41.42 which was greater than the post test PBS mean value for Group B 38.21. P value is less than 0.05 that indicate significant results.

Table 5 between groups Analysis for TUG Independent T test.

Outcome Measure	N	Treatment Groups				T values	P Value
		Group A		Group B			
		Mean	SD	Mean	SD		
TUG Before treatment	28	13.57	1.65084	13.92	1.384	-.620	0.253
TUG After treatment		9.7857	1.311	11.87	1.292	-4.209	0.758

Before test TUG score for Lower Limb Fitness Program (Group A) as 13.57and standard deviation of 1.65084and for Routine Therapy (Group B) mean value was 13.92 and standard deviation of 1.384. The post test TUG mean value for Group A was 9.78 which was less than the post test TUG mean value for Group B 11.87. P value is greater than 0.05 that indicate not significant results.

Table 6 between groups Analysis for CTSIB independent T test

Outcome Measure	N	Treatment Groups				T values	P Value
		Group A		Group B			
		Mean	SD	Mean	SD		
CTSIB Before treatment	28	78.21	17.38	78.21	17.38	.000	1.000
CTSIB After treatment		140.35	13.07	93.92	20.20	7.217	0.05

Before test CTSIB score for Lower Limb Fitness Program (Group A) as 78.21 and standard deviation of 17.38 and for Routine Therapy (Group B) mean value was 78.21 and standard deviation of 17.38. The post test CTSIB mean value for Group A was 140.35 which was greater than the post test CTSIB mean value for Group B 93.92. P value is equal to 0.05 that indicate significant results.

Paired t test

Table 7 within group analysis of PBs (paired t test)

Outcome measure		Assessments				P value
	N	**Baseline**		**After 6 weeks**		
PBS (Experimental group-A)	14	Mean	SD	Mean	SD	
		32.50	4.48	41.42	3.17	0.000
	N	Baseline		After 6 weeks		
PBS (Control group-B)	14	Mean	SD	Mean	SD	
		8.28	1.81	1.50	0.51	0.781

Results showed that the mean value of pre-test of 32.50 and post- test of 41.42 and standard deviation 4.48 and 3.17 respectively of PBS in group A. Inter group investigation of group B for PBS results showed that the mean value of pre-test of 8.28 and post- test of 1.50 and standard deviation 1.81 and 0.51 respectively of PBS in group B.

Table 8 within group analysis for TUG test

Outcome measures		assessments				P value
	N	Before treatment		After treatment		
TUG (Experimental Group A)	14	Mean	SD	Mean	SD	
		13.57	1.65	19.92	1.68	0.05
	N	Baseline		After 6 weeks		
TUG (Control Group B)	14	Mean	SD	Mean	SD	
		35.21	5.83	37.35	5.55	0.00

Results showed that the mean value of pre-test of 13.57 and post- test of 19.92 and standard deviation 1.65 and 1.68 respectively of TUG in group A. Before test of 35.21 and post- test of 37.78 and standard deviation 5.83 and 5.55 respectively of TUG in group B.

P value of post treatment Experiment group was less than 0.05 that indicate result were significant. While P value of Group B was 0.05 which indicate results were significant.

Table 9 within group analysis for CTSIB test

Outcomes		Assesments				P-value
	n	Before treatrment		After treatment		
CTSIB (Experimental group)	14	Mean	SD	Mean	SD	
		78.21	17.38	140.35	13.07	0.00
	N	Baseline		After 6 weeks		
CTSIB (Control Group B)	14	Mean	SD	Mean	SD	
		13.92	1.38	11.85	1.29	0.03

Results explored that the mean value of pre-test of 78.21 and post- test of 140.35 and standard deviation 17.38 and 13.07 respectively of CTSIB in group A. Inter group analysis of group B for CTSIB results presented that the mean value of pre-test of 13.92 and post- tests of 11.85 and standard deviation 1.38 and 1.29 respectively of PBS in group B.

P value of post treatment of group 1 experiment group was less than 0.05 was highly significant.

Above pie chart symbolizes the gender distribution of children, off which 15 (53.57%) were male while 13 (48.43%) were female.

The average age of the children was 8.25± 1.818 years, as shown in the histogram. Children with Down syndrome had a minimum age of six and a maximum age of twelve.

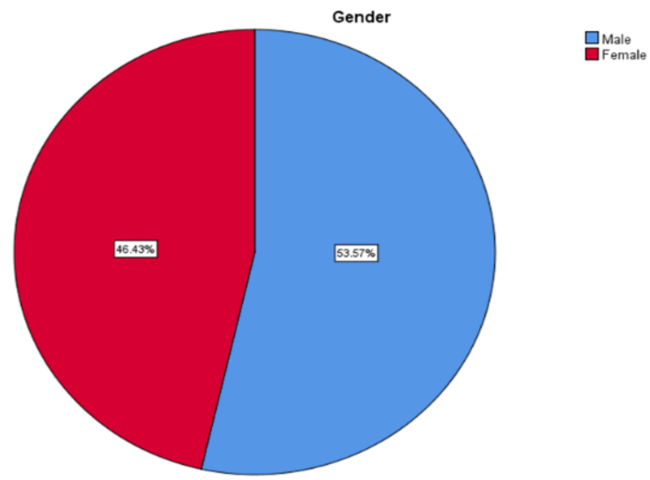
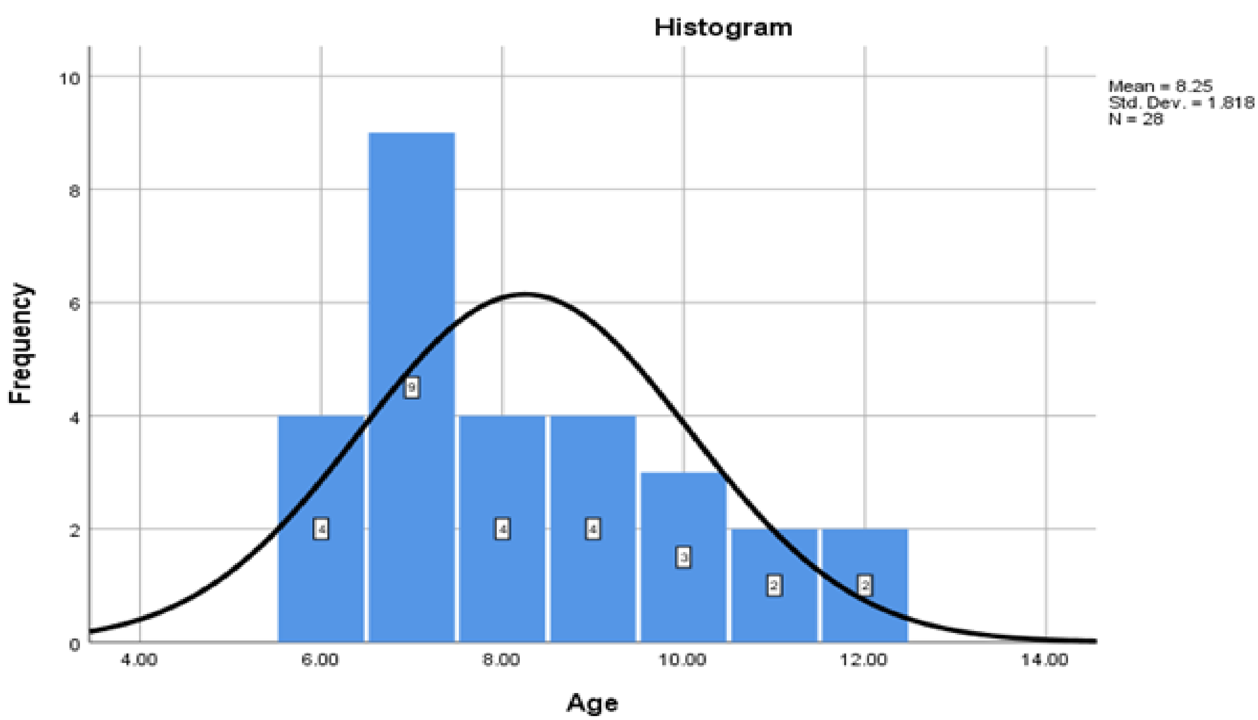


Figure 1 Gender Distribution:



Furthermore, by incorporating machine learning techniques into lower limb fitness programs for children with Down syndrome, we can significantly advance the field. This integration involves collecting comprehensive data, including wearable sensor data, clinical assessments, and demographic information. Through feature engineering, we can extract meaningful insights from this data, enabling the development of predictive models using algorithms like Random Forest, Support Vector Regression, and LSTM networks. These models can predict future balance and mobility performance, estimate improvement, and identify potential risks. By leveraging these insights, we can personalize fitness programs, adapt training regimens in real-time, and implement early interventions. This data-driven approach not only enhances the objectivity and efficacy of assessments but also empowers clinicians to provide targeted and effective interventions, ultimately improving the quality of life for patients with Down syndrome.

DISCUSSION

The findings indicated that with Routine therapy was more effective as compared to Routine Therapy because an obvious significant difference was found between them.

Primary Outcome of current study was measured Dynamic Balance and mobility by Pediatric balance scale, CTSIB and TUG test. Results of current study stated that Lower Limb fitness Program along with Routine therapy had statistically significant effects on Dynamic balance ($p \leq 0.05$) while on mobility statistically not significant ($p > 0.05$).

Patients with Down syndrome experiences more change in dynamic balance and mobility, which emphasize the importance of Lower Limb Fitness Program. There was a significant change in Pediatric balance scale, Time Up and Go test and CTSIB scores in Lower Limb Fitness Program along with Routine therapy between pre and post as compared to Routine therapy. The P value was >0.05.

In previous study result showed that squat to stand training not significantly improve lower extremity muscle power in Down syndrome patients (24). While in current study both treatment protocols showed improvement but the protocol involving Lower Limb Fitness Program along with Routine therapy showed more effectiveness as compared to Routine Therapy.

Findings study conducted by Abinaya K et.al in 2024 to evaluate the benefits of strengthening and aerobic activities for people with Down syndrome. Result was shown that increasing exercise had a demonstrable beneficial impact on the functional mobility of people with Down syndrome (49). Similar was in the current study Lower Limb Fitness program showed more improvement in mobility.

Previous study discovered by Rehman cheema et.al in 2023 on Children with DS showed considerable improvements in balance and coordination with core stability training and retro walking (53). While Findings of current study showed improvement in dynamic balance that were compatible with the pervious study.

Previous study discovered by Abinaya K et.al in 2024 it was shown that increasing exercise had a demonstrable beneficial impact on the functional mobility of people with Down syndrome (49).While findings of current study showed improvement in mobility but statistically not significant.

Pervious research discovered by Eid et al. showed that isokinetic training program improvement in muscle strength, balance and overall functional mobility (17). Compatible to current study showed that lower limb fitness program helped down syndrome patients for improving balance and overall functional mobility.

Conclusion: Lower Limb Fitness Program significant potential for improving mobility and dynamic balance in children with Down syndromes. So, research conducted that group who received Lower Limb fitness Program along with Routine therapy showed more improvement in outcome measures like PBS, TUG and CTSIB as compared to the group who received Routine therapy Exercises.

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