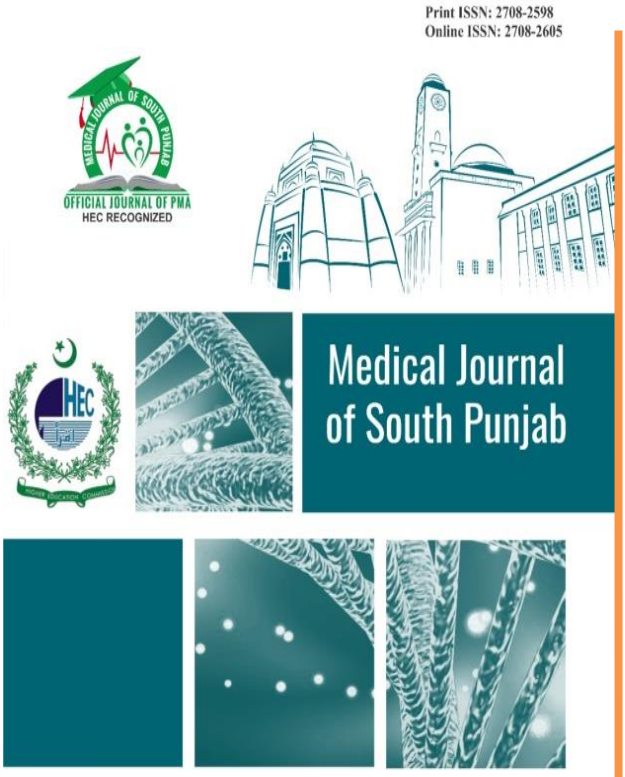
ISSN (E): 2708-2601
ISSN (P): 2708-2598

Medical Journal of South Punjab
Article DOI:10.61581/MJSP.VOL07/03/04
Volume 7, Issue 3, 2026



Effectiveness of conventional physical therapy and backward chaining for improving functional independence in patients with Down syndrome

Publication History

Received: Sep 03, 2026 Revised: Sept 19, 2026
Accepted: Sep 29, 2026 Published: Sep 30, 2026

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Conflict of Interest:

Author(s) declared no conflict of interest.

Acknowledgment:

No Funding received.

Citation: Choudhary S, Rashid S. Effectiveness of conventional physical therapy and backward chaining for improving functional independence in patients with Down syndrome. Medical Journal of South Punjab. 2026 Septemeber 30; 7(3):73-89.

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An official publication of
Medteach Private Limited, Multan, Pakistan.
Email: farman@mjsp.com.pk, Website: https://mjsp.com.pk/index.php/mjsp

Medical Journal of South Punjab
Volume 7, Issue 3, 2026; pp: 73-89
Original Article

Effectiveness of conventional physical therapy and backward chaining for improving functional independence in patients with Down syndrome

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ABSTRACT

Objective: To compare the effectiveness of conventional physical therapy combined with treadmill training and the same intervention supplemented with backward chaining for improving functional independence in children with Down syndrome.

Methods: A RCT was performed at Kehkashan Educational and Training Centre for Special Children, Multan. There was 57 complete children (group A = 28; group B = 29) from a total of 60 enrolled children aged 4-8 years. The two groups were Group A (conventional physical therapy and backward chaining treadmill training) and Group B (conventional physical therapy and treadmill training). The sessions that both groups attended occurred four times a week for 20-40 minutes. The Pediatric Evaluation of Disability Inventory (PEDI) was used to measure functional independence. Paired and independent samples t-tests were performed to analyse the data using IBM SPSS Statistics 26.

Results: Both groups demonstrated significant improvements in total PEDI scores (Group A: 8.11 to 12.54, mean change = 4.429; Group B: 8.00 to 13.79, mean change = 5.793; both $p < 0.001$). Improvements were also significant in Self-Care, Mobility and Social Function in both groups (all $p < 0.001$). Group B completed a significant greater total score post intervention than Group A (13.79 vs. 12.54; $p = 0.025$). Total change scores also were different, 5.79 compared to 4.43, $p = 0.007$. However, there were no significant between-group differences in the changes that occurred with each individual domain.

Conclusions: Both interventions had positive effect on children with Down syndrome's functional independence. The combined backchaining with standard physical therapy and treadmill training, however, significantly improved overall PEDI scores, indicating a benefit in functional independence from the combined approach.

Keywords: Down Syndrome, Functional Independence, Postural Balance, Rehabilitation, Randomized Controlled Trial, Gait

1. INTRODUCTION

Down syndrome (DS) is a genetic disorder characterized by an extra copy of chromosome 21, and is one of the most common genetic causes of intellectual disability. It happens in pregnancy women, meaning that approximately 1 in every 700 to 1,000 live births worldwide was affected[1, 2]. Children with DS frequently have weak muscles and temperamental laxity, impaired postural control, reduced motor development, poor balance, poor gait and are less self-mobile in relation to the ability to perform activities of daily living by them[3, 4]. These constraints often lead to reliance on others and to a limitation in many children's involvement in daily life activities. Thus, interventions aimed to enhance functional independence and physical performance are necessary to incorporate in children with DS' everyday functioning and quality of life[5].

Previously soft tissue massage has been shown to help enhance the motor development, gait, balance and functional mobility in children with DS, as has treadmill training. The effectiveness of treadmill training on promoting independent walking in infants born with DS has been reported in previous studies and greater stepping improvements and physical activity after structured treadmill interventions were shown [6, 7, 8]. Positive relationships between treadmill training and gait and motor development have also been noted but with a number of limitations related to intervention protocols and study quality [9, 10]. Physical rehabilitation is not the only area that backward chaining has shown to be effective at training new skills, as functional and self-care skills have been shown to work well as well[11]. When attempting to teach a functional or self-care skill, an intervention that breaks down that task into smaller steps is considered.This technique was proven to improve the ability of users to press the buttons independently. Chaining in turn has been connected with better functioning of daily living skills for children with developmental disabilities[12]. Most studies, however, have examined physical rehabilitation and backward chaining separately, with few studies examining the effects of the two combined[13, 14].

Physical mobility along with the capability of carrying out activities of living is required for achieving functional independence. Backward chaining can potentially be helpful in creating independence as simple chores, and while conventional physical therapy plus treadmill training offers help for muscular strength, balance and gait, it also offers additional support by systematically moving towards independence in real-world activities[15]. These may thus interact and supplement each other in addressing different, but complementary aspects of functional performance. Data to compare them for their effectiveness in children with DS, however, is rather sparse. Thus, this randomized controlled trial sought to test the benefits of the conjunction of backward chaining with standard PT and treadmill exercise to improve functional independence in children with DS, ages 4-8 y. Functional outcome was evaluated using Pediatric Evaluation of Disability Inventory (PEDI) and compared in the children receiving the combined intervention and those receiving the combined intervention and treadmill training.

2. METHODOLOGY

A randomized controlled trial (RCT) was used comparing the use of traditional physical therapy (TPT) with TPT and backward chaining (BC) on the effects it had. The study took place at Kehkashan Educational and training Centre for Special Children in Multan during Four months which included recruitment of children, intervention and outcome assessment.

The first sample is 66 children. Sixty participants were enrolled and randomly divided into two groups (n = 30 for each group) after passing the eligibility test. A sample size estimation was carried out with G*Power using an effect size of 0.5, a Type I error probability of 0.10, and statistical power of 0.60 and an equal allocation of groups.

The sampling type was purposive sampling then simple random sampling was used between two intervention groups.

Children aged from 4-8 years were included, who have been diagnosed with Down syndrome and are able to follow instructions with medical clearance for physical training.

Children with medical complications which are serious enough to exclude them from treadmill use, childhood musculoskeletal disease severe enough to exclude the child from treadmill participation and/or other intensive childhood rehab programmes were excluded.

Parents/guardians gave written informed consent. Data regarding demographic characteristics such as age, gender, height, weight and medical history was collected. Functional independence has been evaluated before and after intervention by Pediatric Evaluation of Disability Inventory (PEDI) self-care, mobility and social function domains. All participants were randomly allocation to one of two groups: Group A, conventional physical therapy and treadmill training; and Group B, conventional physical therapy and treadmill training plus backward chaining. Both groups attended 4 sessions a week for 12 weeks, each session for 20 – 40 minutes. One month follow up assessment was planned as well.

Data were analysed in IBM SPSS Statistics version 26. Means, standard deviations, frequencies and percentages were computed. The Shapiro–Wilk test was used to determine normality. Within group comparisons were conducted using paired and between group comparisons using independent samples t-tests. A p value < 0.05 was considered statistically significant.

3. RESULTS

The results of a randomized control trial (RCT) examining the effects of pairing conventional physical therapy with the addition of backward chaining (Group B) compared with only treadmill training (Group A) in children with a diagnosis of Down syndrome are presented. There were 60 who were originally enrolled, of which 57 completed the 12-week intervention (Group A was 28 and Group B was 29). Functional independence was measured by three scores from the Pediatric Evaluation of Disability Inventory (PEDI) subscales Self-Care, Mobility and Social Function. IBM SPSS Statistics (version 22) was used to analyze the data and the level of significance was considered with $p < 0.05$. The mean age of the children and adolescents that participated in this study was 5.95 ± 1.294 years (a range of 4–8 years). Mean height was 107.457 ± 10.778 cm, and mean weight was 20.852 ± 4.110 kg. The sample included 30 males (50%) and 30 females (50%).

Independent samples t-tests showed no significant baseline differences between Group A and Group B in age ($t = -0.495$, $p = 0.622$), height ($t = 0.124$, $p = 0.902$) or weight ($t = -1.098$, $p = 0.277$). There were similarities across the groups prior to intervention as seen in these findings. Adjacent data was subjected to Shapiro–Wilk test for normality of the PEDI Total scores. The variables were normally distributed in both groups ($p < 0.05$). In pre-intervention scores, $p = 0.182$ and $p = 0.245$ for groups A and B, respectively, and $p = 0.221$ and $p = 0.123$ for the change scores.

There was a statistically significant improvement on overall PEDI score for both groups after the intervention. Group A increased from 8.11 (SD = 1.641) to 12.54 (SD = 1.915), with a mean gain of 4.429 points ($t = -13.064$, $df = 27$, $p < 0.001$). Group B improved from 8.00 (SD = 1.581) to 13.79 (SD = 2.177), showing a larger mean gain of 5.793 points ($t = -16.773$, $df = 28$, $p < 0.001$). Both interventions led to functional improvements but the higher improvement in Group B suggests the addition of backward chaining may be necessary.

Table 1: Paired Samples T Test for PEDI Total Score

	Measure	Mean	SD	p
Group A	Pre PEDI Total	8.11	1.641	< 0.001
	Post PEDI Total	12.54	1.915	
Group B	Pre PEDI Total	8.00	1.581	< 0.001
	Post PEDI Total	13.79	2.177	

Table 2: Paired Samples T Test for PEDI Domain Scores

	Domain	Pre-Mean (SD)	Post Mean (SD)	p
Group A	Self-Care	2.75 (0.928)	4.14 (1.458)	< 0.001
	Mobility	2.64 (1.096)	4.11 (1.257)	< 0.001
	Social Function	2.71 (0.897)	4.29 (1.150)	< 0.001
Group B	Self-Care	2.93 (0.884)	4.72 (1.251)	< 0.001
	Mobility	2.55 (0.985)	4.48 (1.526)	< 0.001
	Social Function	2.52 (0.986)	4.59 (1.476)	< 0.001

The group effect was also significant in all three functional domains, as in both groups significant improvements were noted (all $p < 0.001$). For Group A, the highest score improvement was seen in Social Function (1.571), Mobility (1.464) and Self-Care (1.393). Similar trends were observed for Group B, with increases in the areas of: Social Function (2.069), Mobility (1.931) and Self-Care (1.793). There was overall greater mean gain in Group B suggesting backward chaining may improve gains in various domains of daily functioning. But the between-group change score analysis needs to be considered to determine whether such differences between groups were statistically significant.

A comparison of baseline scores revealed no significant differences between groups in Self-Care ($p = 0.454$), Mobility ($p = 0.743$), Social Function ($p = 0.434$) or total PEDI ($p = 0.803$). This means the groups preintervention functional scores were similar. After intervention, the mean scores were higher in all the domains of Group B.

Table 3: Independent Samples T Test for PEDI Domain Scores Between Groups

Variable	Group A (n=28) Mean (SD)	Group B (n=29) Mean (SD)	p
Pre Self Care	2.75 (0.928)	2.93 (0.884)	0.454
Post Self Care	4.14 (1.458)	4.72 (1.251)	0.112
Pre Mobility	2.64 (1.096)	2.55 (0.985)	0.743
Post Mobility	4.11 (1.257)	4.48 (1.526)	0.316
Pre Social Function	2.71 (0.897)	2.52 (0.986)	0.434
Post Social Function	4.29 (1.150)	4.59 (1.476)	0.396
Pre PEDI Total	8.11 (1.641)	8.00 (1.581)	0.803
Post PEDI Total	12.54 (1.915)	13.79 (2.177)	0.025

For the variables of Self-Care ($p = 0.112$), Mobility ($p = 0.316$) and Social Function ($p = 0.396$), however, there were no statistically significant differences between males and females. In contrast, the total PEDI score was significantly higher in Group B ($M = 13.79$, $SD = 2.177$) than Group A ($M = 12.54$, $SD = 1.915$), with a mean difference of 1.25 points ($t = -2.312$, $df = 55$, $p = 0.025$). This means that the between-group advantage was statistically significant in Functional Performance but not for any one domain. The total scores of the pre and post-tests for Levene's test were not significant for either pre ($F = 0.175$, $p = 0.677$) or post ($F = 0.119$, $p = 0.732$) suggesting that the variances were equal.

Differences in improvement were directly assessed using a change score comparison. Group B achieved greater mean increase in total PEDI score (5.79, $SD = 1.859$) than Group A (4.43, $SD = 1.794$).

Table 4: Independent Samples T Test for Change Scores Between Groups

Variable	Group A Mean (SD)	Group B Mean (SD)	p
Change PEDI Total	4.43 (1.794)	5.79 (1.859)	0.007
Change Self Care	1.39 (1.066)	1.79 (0.978)	0.145
Change Mobility	1.46 (0.922)	1.93 (0.998)	0.072
Change Social Function	1.57 (1.034)	2.07 (1.280)	0.113

This difference of ~1.36 points was statistically significant (t = -2.819, df = 55, p = 0.007) and thus shows additional benefit of backward chaining in combination with conventional physical therapy and treadmill training.The three differences, at the domain level for the domains of Self-Care, Mobility, and Social Function, did not prove to be statistically significant (p = 0.145, p = 0.072 and p = 0.113, respectively). Therefore the results suggest that there was a significant difference statistically between the groups in terms of overall functional improvement, however, there was no statistically significant best outcome in any specific PEDI domain.

4. DISCUSSION

The current study investigated the effectiveness of physical therapy with treadmill training that was compared with physical therapy with treadmill training and backward chaining (BC) for functional independence in children with Down syndrome (DS). Both groups' results showed significant improvement in the total sum of PEDI scores and on all three functional domains. There was however a much more significant improvement on overall functional independence in Group B.Group A's total PEDI score increased from 8.11 to 12.54, with a mean improvement of 4.429 points (p < 0.001). This helps to compensate for the effectiveness of the conventional physical therapy and the training on the treadmill. Other studieshave noted benefits of safe walking development and stepping upon treadmill interventions in children with DS. Other positive physical activity changes after treadmill training were also noted[11]. The results indicate that repeated stepping practice could play a role in helping to enhance mobility and functional capabilities. In individuals with DS, the use of a treadmill for training has also been shown to have benefits, as found in the systematic review [6, 16].

On total PEDI score Group B achieved an improvement from 8.00 to 13.79 (Mean: 5.793 points) which proved to be significant (p<0.001). Both the between-group difference and the total change scores (5.79 versus 4.43; p = 0.007) were statistically different between groups at post-intervention data. These results showed that the baseline scores are similar (p = 0.803), indicating that there may be an added advantage to using backward chaining. This could be due to the task-based approach used in its approach, which is broken down into teaching steps and lets the children practise and complete activities that may be functional, but step by step[17, 18]. Backward chaining was found by Fiati and Kurniati to have positive results in buttoning[19]and Rehman et al. reported the advantages of chaining procedure for learning skills on self care of children with DS[17].

At the domain level, Group B achieved greater mean improvements in Self-Care (1.793), Mobility (1.931) and Social Function (2.069) than Group A. However, these between-group differences were not statistically significant (p = 0.145, 0.072 and 0.113, respectively). Therefore, the findings demonstrate superiority in overall PEDI improvement but do not establish statistically significant advantages in individual domains. The PEDI's assessment of everyday functioning across multiple areas supports its relevance to evaluating functional outcomes in children with disabilities[20].Limitations include the small sample, recruitment from a single centre and absence of long-term follow-up. Future studies should include larger samples and objective assessments of gait and

balance.Overall, combining backward chaining with conventional physical therapy and treadmill training produced significantly greater improvement in total functional independence than conventional treatment alone.

5. CONCLUSION

Both interventions significantly improved functional independence in children with Down syndrome. However, adding backward chaining to conventional physical therapy and treadmill training resulted in greater improvement in total PEDI scores (5.79 vs. 4.43; p = 0.007). Therefore, the combined approach may provide additional benefits in overall functional independence.

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