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Comparative Effectiveness of Physioball-Assisted Core Stability Exercises and Traditional Exercise on Functional Balance in Children with Developmental Delay: A Pilot Experimental Study

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ABSTRACT

Background: Balance difficulties in children with developmental delay are rarely isolated problems. They usually sit inside a wider picture of delayed postural reactions, reduced trunk control, cautious mobility, and dependence during daily activities. Physiotherapy often begins with traditional developmental positions such as quadruped and kneel standing; however, the addition of physioball-assisted core stability exercises may provide a more active challenge to trunk control and equilibrium reactions. **Objective:** To compare the effects of traditional exercise alone with a combined program of traditional exercise and physioball-assisted core stability exercise on functional balance in children with developmental delay. Methods: A pilot experimental pre-test and post-test design was used. Twenty children aged 3 to 10 years with developmental delay were allocated into an experimental group (n = 10) and a control group (n = 10). The experimental group received traditional exercises combined with core stability exercises using a physioball for 8 weeks, while the control group received traditional exercise alone. Functional balance was measured using the Pediatric Balance Scale, a 14-item pediatric measure scored from 0 to 56. Descriptive statistics, paired t-tests, and between-group change score analysis were used. **Results:** The experimental group improved from a mean PBS score of 43.00 +/- 0.00 to 49.80 +/- 5.37, with a mean change of 6.80 +/- 5.37 points (paired $t = 4.00$, $p = .003$). The control group improved from 42.00 +/- 5.89 to 45.10 +/- 6.15, with a mean change of 3.10 +/- 1.29 points (paired $t = 7.62$, $p < .001$). The mean difference in change scores favored the experimental group by 3.70 points. Using Welch's test, the between-group comparison approached statistical significance ($t = 2.12$, $p = .060$), with a large effect estimate (Hedges' $g = 0.91$). **Conclusion:** Both exercise programs improved pediatric functional balance, but the combined physioball-based core stability program produced a larger average gain. Because of the small sample and the uniform experimental baseline, the findings should be read as clinically promising rather than definitive. A larger randomized trial with concealed allocation, longer follow-up, and item-level PBS analysis is recommended.

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INTRODUCTION:

Children with developmental delay frequently reach motor milestones later than expected, and the delay can be visible in very ordinary situations: a child may sit but use the hands heavily for support, stand but avoid shifting weight, or walk with a guarded pattern that tells the clinician the trunk is not yet giving enough postural security. In pediatric physiotherapy, balance is therefore not treated as a narrow standing skill. It is better understood as a functional expression of trunk control, sensory organization, antigravity activation, attention, confidence, and repeated practice in meaningful positions. This is one reason pediatric rehabilitation often works through play and task-oriented positions rather than through isolated strengthening alone.

The synopsis underlying the present manuscript was designed around children with motor developmental delay aged 3 to 10 years, with the main clinical question asking whether core stability exercise added to traditional exercise improves balance. In that age range, the assessment tool matters. The Pediatric Balance Scale (PBS) is more appropriate than the adult-oriented Berg Balance Scale because it modifies functional balance tasks for children and preserves a familiar 14-item structure with a total possible score of 56 (Franjoine et al., 2003; Yi et al., 2012). The tool is particularly useful in a small clinical trial because it captures tasks that therapists actually observe in pediatric practice, such as sitting to standing, unsupported standing, transfers, turning, alternate foot placement, and forward reaching.

Core stability has a fairly simple clinical meaning, even if the underlying neuromotor control is complex. The abdominal wall, paraspinals, pelvic girdle musculature, diaphragm, and hip stabilizers work together to give the limbs a stable base from which to move. A child who reaches forward while prone over a physioball is not merely strengthening one muscle group; the child is learning to organize the trunk while the centre of mass shifts, the arms leave the support surface, and the visual goal draws movement forward. In the same way, side-to-side sitting on a physioball can invite righting reactions that are difficult to obtain through static mat exercise alone. Akuthota et al. (2008) described core stability as a principle of coordinated control rather than brute strength, and this idea fits well with pediatric developmental practice.

Evidence from pediatric neurological rehabilitation supports the idea that trunk-focused programs can influence balance and related motor outcomes. Elshafey et al. (2022) reported greater improvement in balance and coordination when a core stability program was added to standard therapy in children with cerebellar ataxic cerebral palsy. Mohamed et al. (2025) similarly found that structured core stability training produced superior gains in balance, standing, and gait outcomes in children with mild cerebral palsy. Ali (2019) and Ali et al. (2019) also reported favorable postural control and balance responses following core-focused interventions in children with spastic cerebral palsy. The populations in these studies are not identical to children with developmental delay, but they are clinically relevant because they involve pediatric motor impairment, reduced postural control, and the need for functional balance training.

At the same time, the current literature should not be interpreted too neatly. Children with developmental delay are heterogeneous. Some have genetic diagnoses, some have motor planning difficulties, some show hypotonia or fluctuating tone, and some have attention or behavioural challenges that change how they respond to balance tasks. A small improvement in PBS score may reflect better trunk control, but it may also reflect familiarity with instructions, reduced fear, improved attention, or a more confident therapist-child interaction. For that reason, the present paper treats the data carefully. The aim is not to overclaim that physioball training is a stand-alone solution. Rather, the aim is to examine whether adding a structured physioball-based core stability component to traditional exercise was associated with a larger functional balance gain than traditional exercise alone.

Objectives:

To evaluate the within-group change in Pediatric Balance Scale scores after an 8-week physioball-assisted core stability and traditional exercise program.

To evaluate the within-group change in Pediatric Balance Scale scores after an 8-week traditional exercise program.

To compare the magnitude of PBS change between the experimental and control groups.

To interpret the clinical meaning and limitations of the observed change pattern in the context of pediatric developmental delay.

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Methods:
A pilot experimental pre-test and post-test design was used. The study compared two physiotherapy approaches over an 8-week intervention period. The experimental group received traditional exercise along with physioball-assisted core stability exercises, while the control group received traditional exercise alone. The design is best described as a pilot clinical study because the sample size was small and the dataset was intended to explore treatment response rather than establish a final treatment effect.

The study population consisted of children with developmental delay aged between 3 and 10 years. Children were considered for inclusion when motor developmental delay was present and the parent or legally acceptable representative was willing to provide consent. Children with severe intellectual impairment who could not follow basic commands, severe visual or auditory impairment, or severe quadriplegic cerebral palsy were excluded because these factors would substantially interfere with PBS task performance and safe participation in the exercise program.

The outcome measure was changed from the originally listed Berg Balance Scale to the Pediatric Balance Scale. This is methodologically appropriate because the PBS is designed for pediatric functional balance assessment and retains 14 clinically familiar tasks scored from 0 to 4, giving a maximum score of 56 (Franjoine et al., 2003; Yi et al., 2012). In this study, higher scores indicated better balance performance. The PBS was administered before the start of the intervention and again after completion of the 8-week program.

The experimental intervention included traditional exercises and physioball-assisted core stability exercises. Traditional exercise consisted of stretching when hypertonicity was present, quadruped sustain activities, half-kneeling or kneel-standing activities, and functional postural practice. The core stability component included sitting balance activities on the physioball, forward-backward and side-to-side equilibrium activities, prone positioning over the ball with bilateral reach-out, and kneel-standing or trunk activation tasks. The intention was to create controlled instability rather than unsafe instability. The therapist therefore adjusted the amount of support, task difficulty, and reach distance according to each child's ability.

The control intervention was traditional exercise alone over the same general intervention period. This allowed the analysis to ask a practical clinical question: does adding a physioball-based core stability component provide additional benefit beyond conventional pediatric physiotherapy activities? Because the groups were small and real-world clinical data were used, the analysis focused on transparent descriptive and inferential statistics rather than complex modelling.

The data were analysed using descriptive statistics for age, pre-test PBS score, post-test PBS score, and change score. Paired t-tests were used for within-group pre-post comparisons. Between-group change was examined using Welch's independent-samples t-test because the variability of the change score differed between groups. A pooled independent t-test and Mann-Whitney U test were also examined as sensitivity checks, but the Welch test was treated as the more cautious primary comparison. Statistical significance was interpreted at $p < .05$, while effect size and clinical direction were also considered.

Table 1: Participant characteristics from the working dataset

Characteristic	Experimental group (n = 10)	Control group (n = 10)	Total sample
Age, mean +/- SD years	6.05 +/- 2.45	6.05 +/- 2.45	6.05 +/- 2.39
Age range, years	3.0-10.0	3.0-10.0	3.0-10.0
Sex recorded in dataset	Male = 4, female = 1, missing = 5	Male = 5, female = 5	Male = 9, female = 6, missing = 5
Outcome measure	Pediatric Balance Scale	Pediatric Balance Scale	Pediatric Balance Scale

Table 2: Pediatric Balance Scale scores before and after intervention

Group	Pre-test PBS mean +/- SD	Post-test PBS mean +/- SD	Mean change +/- SD	Median change	Minimum-maximum change
Experimental	43.00 +/- 0.00	49.80 +/- 5.37	6.80 +/- 5.37	9.00	-3 to 13
Control	42.00 +/- 5.89	45.10 +/- 6.15	3.10 +/- 1.29	3.00	2 to 6

Table 3: Inferential analysis of PBS change

Comparison	t statistic	df	p value	Interpretation
Experimental pre-test vs post-test	4.00	9	= .003	Significant within-group improvement
Control pre-test vs post-test	7.62	9	< .001	Significant within-group improvement
Between-group change, Welch test	2.12	10.03	= .060	Favored experimental group; approached significance
Between-group change, Mann-Whitney U	U = 69.5	-	= .148	Non-parametric sensitivity check

Note. The experimental group had a uniform baseline PBS score, which limited baseline variance. For that reason, the between-group finding is interpreted cautiously, even though the mean change favored the experimental program.

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RESULTS:

The average age of the children in both groups was 6.05 years. The age distribution was intentionally broad for a pediatric developmental delay sample, ranging from 3 to 10 years. Sex data were complete in the control group but incomplete in the experimental group; therefore, sex was not included in inferential analysis. The primary outcome was the Pediatric Balance Scale score, and the total possible score was 56.

In the experimental group, the mean PBS score increased from 43.00 to 49.80 after the 8-week program. The average change was 6.80 points, but the response was not identical across children. Some children gained 9 to 13 points, suggesting a clear functional response, while one child showed a reduced post-test score. This variation is clinically believable in pediatric rehabilitation because attention, fatigue, task tolerance, cooperation, and day-to-day motor performance can all influence functional balance testing.

In the control group, the mean PBS score increased from 42.00 to 45.10, with an average gain of 3.10 points. The control group improvement was smaller but more consistent; every child improved by at least 2 points. Traditional exercise therefore cannot be dismissed. It appears to have produced a stable benefit, though the average magnitude of improvement was less than that observed in the combined program.

The paired t-test showed significant improvement within both groups. The experimental group showed a statistically significant pre-post improvement ($p = .003$), and the control group also showed a statistically significant improvement ($p < .001$). The between-group comparison of gain scores favored the experimental group by 3.70 points. With Welch's correction, the difference approached but did not cross the conventional $p < .05$ threshold ($p = .060$). The effect estimate, however, was large (Hedges' $g = 0.91$), suggesting that the observed difference may be clinically meaningful and worth testing in a larger sample.

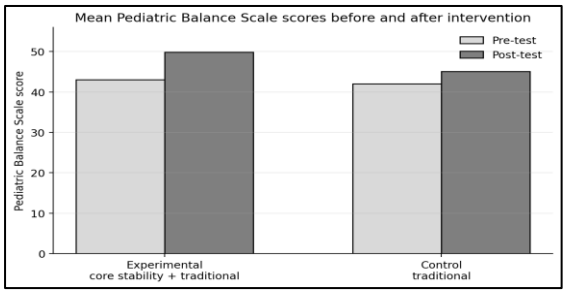

Figure 1. Mean Pediatric Balance Scale scores before and after intervention.

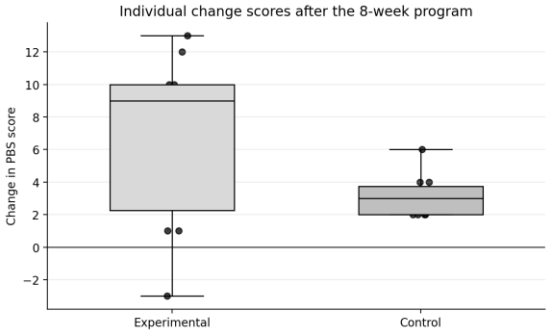

Figure 2. Distribution of individual PBS change scores in the experimental and control groups.

DISCUSSION:

The central finding of this pilot study is straightforward but not simplistic. Both groups improved, which means traditional pediatric physiotherapy activities had value. Yet the group that received physioball-assisted core stability exercise in addition to traditional exercise showed a larger average PBS gain. Clinically, that pattern makes sense. Traditional postural positions such as quadruped, half-kneeling, and kneel standing are useful because they build antigravity control and transitional stability. The physioball, however, adds a slightly different ingredient: controlled movement under instability. It asks the child to solve a balance problem while the support surface changes, and this may stimulate trunk activation, righting reactions, anticipatory control, and confidence with weight shift.

The PBS improvement in the experimental group is consistent with the broader rehabilitation literature. Elshafey et al. (2022) found that adding core stability exercise to standard therapy improved balance and coordination more than standard therapy alone in children with cerebellar ataxic cerebral palsy. Mohamed et al. (2025) reported superior balance, standing, and gait outcomes in children with mild cerebral palsy after structured core stability training. Similarly, Al-Nemr and Kora (2024) found that core stabilization produced meaningful balance benefits in children with cerebral palsy. Although cerebral palsy and developmental delay are not interchangeable diagnoses, these findings support the clinical argument that trunk-centered training can influence functional balance in pediatric neurorehabilitation.

The stronger mean gain in the experimental group should still be interpreted with caution. The pre-test PBS score in that group was identical for all 10 children, which is unusual in real clinical data and reduces the ability to examine baseline variability. It also makes correlation-based analysis impossible for that group. Because of that, the paper reports the pattern transparently rather than treating the result as a final proof. A larger study should avoid this

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limitation by using independent blinded assessors, checking score entry carefully, and recording item-level PBS scores rather than total score alone.

Another interesting point is that the control group improved significantly despite receiving no physioball core stability component. This is not a weakness of the study. It is a reminder that developmental positions, stretching when needed, quadruped sustain, and kneel-standing activities remain meaningful components of pediatric physiotherapy. In a child who has delayed motor development, repeated practice in these positions can improve postural orientation and confidence. The added value of the physioball may therefore lie not in replacing traditional exercise, but in enriching it.

From a clinical perspective, physioball activities may be especially useful when the child can already tolerate supported sitting, prone positioning, or kneel-standing but has difficulty with dynamic balance demands. Prone reach-out with bilateral hands, for example, gives the therapist a playful way to ask for trunk extension, shoulder stability, and forward weight shift. Sitting side-to-side on the ball can make righting reactions visible. Kneel-standing can be progressed with reaching, visual targets, and reduced manual support. These activities are not glamorous; they are small, repeated, carefully graded problems. Yet pediatric rehabilitation often changes through exactly those small repeated problems.

The findings also have practical implications for outcome measurement. The Pediatric Balance Scale captured change in both groups and was better aligned with the age and functional profile of the participants than the adult Berg Balance Scale. Yi et al. (2012) supported the validity of pediatric balance scales in children with spastic cerebral palsy, and Franjoine et al. (2003) originally described the PBS as a child-adapted version of the Berg format. For a dissertation or journal manuscript involving children aged 3 to 10 years, PBS is therefore a defensible and more appropriate choice.

The limitations are important. The study involved only 20 children, no long-term retention testing, incomplete sex data in the experimental group, and no item-level PBS analysis. The statistical result for between-group change was close to significance but not conventionally significant under the more cautious Welch test. The study also did not record adherence, therapist support levels, or adverse events in a way that would allow a full feasibility analysis. These details matter because pediatric outcomes depend not only on which exercise is prescribed, but also on how much assistance is given, how the child attends to the task, and whether the family continues similar activities at home.

Even with these limits, the study provides a useful starting point. The result does not say that a physioball is a magic tool. It says something more modest and more clinically believable: when used thoughtfully, physioball-assisted core stability exercise may add a meaningful dynamic balance challenge to traditional pediatric physiotherapy. That is enough to justify a larger controlled study with stronger measurement procedures.

Clinical Implications:
The combined intervention can be considered when a child with developmental delay can safely participate in supported physioball activities and has sufficient command following for PBS-related tasks. Therapists should grade the activity carefully, begin with safe support, and progress toward reduced manual assistance only when postural control improves.

Traditional exercise should remain part of the program. The control group improved, and this supports continued use of developmental postures such as quadruped and kneel standing. The physioball component is best viewed as an adjunct that may increase dynamic trunk demand and engagement.

PBS should be retained as the primary balance outcome in future versions of the study. Item-level scoring would be useful because it could show whether improvement is coming mainly from sitting-to-standing, standing balance, turning, reaching, or alternate foot placement tasks.

CONCLUSION:

In this pilot experimental study, both traditional exercise and the combined program of traditional plus physioball-assisted core stability exercise improved functional balance in children with developmental delay. The combined program produced the larger mean PBS gain and a large effect estimate, although the between-group comparison approached rather than reached statistical significance using Welch's test. The result supports the use of Pediatric Balance Scale as the outcome measure and suggests that physioball-based core stability work deserves further study as an adjunct to traditional pediatric physiotherapy.

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before submission to a journal.

CONFLICT OF INTEREST:

The authors declare no conflict of interest for this manuscript draft.

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