RESEARCH PAPER

Physioball-Based Core Stability Training for Functional Balance in Pediatric Developmental Delay: A Clinical Protocol and Outcome Trend Analysis Using the Pediatric Balance Scale

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Abstract

Background: Physioball training is frequently used in pediatric physiotherapy because it can make trunk control practice active, playful, and graded. Yet physioball exercise should not be presented as a general activity without clinical structure. In children with developmental delay, the therapeutic value lies in how the ball is used to provoke safe righting reactions, forward reach, postural holding, and controlled transitions.

Objective: To describe a physioball-assisted core stability protocol for children with developmental delay and to analyse the functional balance trend observed after an 8-week intervention period using the Pediatric Balance Scale.

Methods: This paper presents a thesis-derived clinical protocol and outcome trend analysis. Twenty children aged 3 to 10 years were included in the working dataset. Ten children received a combined physioball-assisted core stability and traditional exercise program, while ten children received traditional exercise only. The primary clinical focus of this paper is the structure and interpretation of the experimental protocol: kneel standing, prone positioning with bilateral hand reach-out, sitting balance on the physioball, and forward-backward and side-to-side balance challenges. PBS change scores were used to describe response patterns.

Results: The physioball-assisted group improved by a mean of 6.80 PBS points, while the traditional exercise group improved by 3.10 points. In the physioball-assisted group, 7 of 10 children improved by 6 or more points, 2 improved by 1 point, and 1 child showed a reduction. The control group showed smaller but consistent gains, with all children improving by 2 to 6 points. The findings suggest that physioball-assisted core stability training may create a stronger balance stimulus, although response variability must be expected in pediatric developmental populations.

Conclusion: A structured physioball protocol can be integrated into pediatric physiotherapy for children with developmental delay when safety, grading, and task-specific goals are clearly defined. The observed PBS trend favors the combined program, but future work should include item-level PBS scoring, adherence records, therapist assistance grading, and follow-up testing.

Keywords: physioball; core stability protocol; pediatric developmental delay; Pediatric Balance Scale; trunk control; balance rehabilitation

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Introduction

Physioball exercise can look deceptively simple. A child sits on the ball, the therapist gives support, and the child tries to remain upright. From outside, it may look like a playful balancing task. Clinically, however, a well-designed physioball activity is much richer than that. It alters the support surface, changes the relationship between pelvis and trunk, invites weight shift, and asks the child to organise the body before reaching, turning, or correcting posture. For children with developmental delay, these small postural challenges can be meaningful because delayed balance is often tied to reduced trunk control and limited confidence during transitions.

The present paper was prepared as a second thesis-derived manuscript. It deliberately takes a different angle from a conventional comparative effectiveness article. Instead of focusing only on statistical significance, it describes the clinical logic of the physioball-assisted core stability program and links that logic to observed Pediatric Balance Scale outcomes. This is useful because pediatric physiotherapy interventions are not only defined by exercise names. Two therapists may both write 'prone on ball reach-out' in a protocol, but the effect on the child can differ depending on ball size, therapist support, reach distance, attention strategy, and progression.

Children with developmental delay form a broad group. Some children show delayed sitting and standing milestones; others have difficulty with transitions, equilibrium reactions, or motor planning. Balance training in this population therefore needs to be safe enough for children with immature postural control but interesting enough to invite active participation. The physioball can help with that balance. It allows the therapist to create movement while the child is supported, and it can convert a static posture into a controlled dynamic task.

Trunk control is increasingly recognised as a key target in pediatric neurorehabilitation. Park et al. (2023) reported that neurodevelopmental treatment-based trunk control exercise improved gross motor function and trunk control in children with developmental disabilities. Elshafey et al. (2022) found that core stability exercise improved balance and coordination when added to standard physical therapy in children with cerebellar ataxic cerebral palsy. The systematic review by Zhou et al. (2024) suggested that core stability exercises may improve dynamic balance in children and adolescents with intellectual disabilities, although the certainty of evidence was low. The available evidence therefore supports the clinical plausibility of core stability training while still leaving room for cautious interpretation.

Outcome measurement also deserves attention. The Pediatric Balance Scale is more suitable for this work than the adult Berg Balance Scale because it was developed for children and uses functional tasks that reflect everyday balance demands (Franjoine et al., 2003). The scale includes sitting-to-standing, transfers, unsupported standing, standing with eyes closed, tandem stance, one-leg stance, turning, retrieving an object from the floor, alternate foot placement, and forward reach. These items match the movement problems that physiotherapists often address in developmental delay, which makes PBS a strong practical outcome measure for a physioball-based intervention study.

Clinical Rationale for the Physioball Protocol

The first rationale is controlled instability. A stable floor or plinth can teach a child to hold posture, but it may not always stimulate timely righting reactions. The physioball gives the therapist a way to introduce instability gradually. The child does not need to be thrown into a challenging activity; even a small pelvic movement on the ball can ask the trunk to respond. When done safely, this can make balance training active without making it frightening.

The second rationale is task-linked trunk activation. Core stability is sometimes misunderstood as abdominal strengthening alone. In pediatric rehabilitation, it is more useful to think of core stability as the child's ability to keep the trunk organised while the limbs perform a task. Prone reach-out with bilateral hands is a good example. The child must extend the trunk, stabilise around the shoulder girdle, visually orient toward the target, and shift weight forward. The exercise therefore links trunk activation to a goal, which is often better tolerated by children than isolated exercise.

The third rationale is progression through play. Children with developmental delay may fatigue, lose interest, or resist repetitive formal commands. A ball, a toy, a visual target, and a short challenge can make the session feel less like testing and more like movement exploration. This does not reduce scientific value; it makes the therapy developmentally appropriate. The challenge for the therapist is to keep the task measurable and consistent while still allowing the child to engage naturally.

Table 1
Physioball-assisted and traditional exercise components proposed for the manuscript

Exercise component	Starting position	Therapeutic purpose	Progression idea	Photograph placeholder
Kneel	Supporte	Pelvic	Add	[Insert

standing	d kneel standing on mat or near plinth	control, trunk extension, antigravity holding, proximal stability	reaching task, reduce hand support, vary object direction	photograph: kneel standing]
Prone on physioball with bilateral reach-out	Child prone over physioball with therapist support at pelvis or trunk	Trunk extension, shoulder stability, forward weight shift, visual-motor engagement	Increase reach distance, use small ball/toy target, reduce support gradually	[Insert photograph: prone bilateral reach-out]
Sitting on physioball	Child sitting on appropriately sized physioball with feet supported when possible	Sitting balance, pelvic mobility, righting reactions	Add forward-backward movement, side-to-side movement, reaching tasks	[Insert photograph: sitting on ball]
Forward-backward and side-to-side ball balance	Supported sitting or semi-supported sitting on physioball	Dynamic equilibrium, anticipatory and reactive postural control	Increase movement amplitude only when safe and controlled	[Insert photograph: dynamic ball balance]
Traditional quadruped and half-kneeling practice	Mat-based developmental positions	Baseline postural control, weight bearing, transition readiness	Add toys, reaching, sustained holds, or short transitions	[Insert photograph: traditional exercise]

Materials and Methods

This manuscript uses the same thesis dataset but presents it from a protocol and clinical outcome perspective. Twenty children aged 3 to 10 years with developmental delay were included. The experimental group received physioball-assisted core stability exercises in addition to traditional exercise, while the control group received traditional exercise only. Both groups were assessed before and after an 8-week intervention period.

The Pediatric Balance Scale was used as the outcome measure. Each of its 14 items is scored from 0 to 4, with higher scores representing better functional balance. The total score can range from 0 to 56. The PBS was chosen because it is appropriate for pediatric balance testing and is clinically easier to defend in a child sample than an adult balance scale.

The physioball protocol was not intended to be a rigid one-size-fits-all list. Instead, each activity was graded according to the child's ability, attention, and safety. The therapist could provide pelvic or trunk support, adjust the ball size, reduce movement amplitude, and use toys or reach targets to encourage participation. Safety was treated as a central part of the protocol. No exercise was considered useful if the child had to struggle in a way that increased fear or risk.

Data analysis focused on PBS change scores and response patterns. Mean, standard deviation, median, minimum, and maximum change were calculated for both groups. Response bands were used to describe clinical patterns: no or negative change, 1 to 3 points, 4 to 6 points, and 7 or more points. This method is descriptive, but it gives the clinician a clearer view of how children responded rather than reducing the entire result to one p value.

Table 2
Summary of Pediatric Balance Scale outcome trend

Group	Pre-test PBS	Post-test PBS	Change score	Response description
Experimental	43.00 +/- 0.00	49.80 +/- 5.37	6.80 +/- 5.37	Larger mean gain, more variable response
Control	42.00 +/- 5.89	45.10 +/- 6.15	3.10 +/- 1.29	Smaller mean gain, more consistent response

Table 3
Distribution of PBS change scores by clinical response band

Response band	Experimental group	Control group	Clinical reading
0 or negative change	1	0	Possible fatigue, poor cooperation, measurement variability, or true decline
1-3 point gain	2	7	Small but positive functional balance shift
4-6 point gain	1	3	Moderate gain likely to be visible in selected tasks
7+ point gain	6	0	Large change requiring closer item-level interpretation

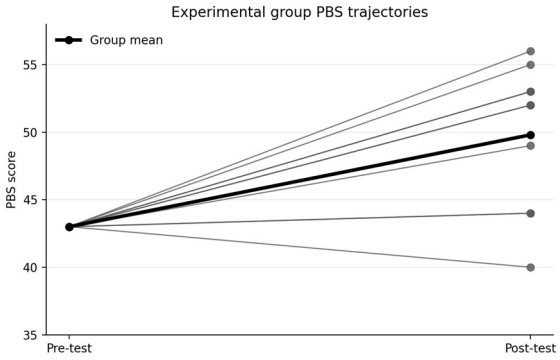

Figure 1. Individual PBS trajectories in the physioball-assisted core stability group.

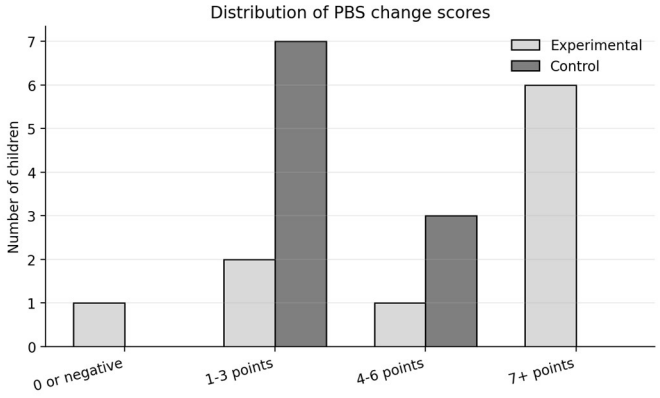

Figure 2. Distribution of PBS change scores by response band.

Results

The physioball-assisted group had a mean pre-test PBS score of 43.00 and a mean post-test score of 49.80. The mean gain was 6.80 points. Looking only at the mean would, however, hide an important detail: response varied noticeably. Seven children improved by 6 or more points, two children improved by 1 point, and one child showed a 3-point decline. This is a clinically important pattern because it suggests the program may produce strong gains in some children while still requiring careful monitoring in others.

The traditional exercise group improved from 42.00 to 45.10, with a mean gain of 3.10 points. The gains were smaller but consistent. Every child in the control group improved, with change scores ranging from 2 to 6 points. This pattern suggests that traditional developmental exercise provides a stable base of benefit, although the larger improvements were more commonly seen in the physioball-assisted group.

When response bands were examined, the physioball-assisted group had more children in the 7+ point gain category, while the control group clustered mostly in the 1-3 point range with a smaller number in the 4-6 point range. This difference is useful clinically because it suggests that physioball-based core stability work may be associated with larger improvements for selected children, not merely a small average shift across the whole group.

The overall trend therefore favors the combined intervention, but it also argues against careless generalization. One child in the experimental group had a lower post-test score, and this matters. Pediatric testing can be influenced by fatigue, mood, fear, illness, attention, or a difficult day at the clinic. A future manuscript would benefit from repeated PBS testing or item-level scoring so that true motor change can be distinguished from day-to-day performance variation.

Discussion

The outcome trend supports the clinical idea that the physioball can be more than a therapy accessory. When the exercise is structured, the ball becomes a tool for graded trunk challenge. Sitting on the ball encourages pelvic mobility and righting reactions. Prone reach-out asks for trunk extension and bilateral upper-limb engagement. Kneel standing builds pelvic and trunk control in a more vertical developmental posture. Together, these tasks may explain why the physioball-assisted group showed a larger average PBS gain than the traditional exercise group.

This interpretation aligns with core stability principles described in the rehabilitation literature. Akuthota et al. (2008) emphasised that core stability depends on coordinated control and endurance, not just isolated strength. In children, that coordination needs to be practised in positions that feel meaningful and achievable. Park et al. (2023) linked trunk control exercise with improvements in gross motor function and trunk control in children with developmental disabilities, which supports the idea that trunk-focused work can influence broader functional movement. Elshafey et al. (2022) and Mohamed et al. (2025) similarly reported improved balance outcomes when core stability training was added to pediatric neurological rehabilitation programs.

The response pattern in this dataset is perhaps more clinically informative than the statistical test alone. The experimental group produced more large gain scores, but it also showed greater variability. That is exactly the sort of finding clinicians recognise. A child who enjoys movement on the ball and understands the task may respond strongly. Another child may become anxious, distracted, or fatigued, and the same exercise might need to be simplified. The physioball protocol should therefore be presented as graded and responsive rather than fixed.

The control group result is also worth respecting. Traditional exercise gave consistent improvement, and that matters for clinical planning. Quadruped, half-kneeling, kneel standing, stretching when indicated, and supported transitions remain basic but powerful pediatric tools. They are accessible, inexpensive, easy to teach to caregivers, and usually safe when properly supervised. The physioball should not replace these activities. It should be used when the therapist wants to increase dynamic trunk demand, make the session more engaging, or progress a child who is ready for a more responsive support surface.

The Pediatric Balance Scale fits the protocol because many PBS items resemble the functional problems targeted in therapy. Sitting-to-standing and transfers relate to trunk and lower-limb coordination. Standing unsupported, standing with eyes closed, and feet-together standing reflect static postural control. Turning, retrieving an object from the floor, alternate foot placement, and reaching forward introduce dynamic demands. A physioball program does not train these items directly as test practice, but it may prepare the underlying control needed for them. That is why PBS is a sensible outcome measure for this type of intervention.

Several limitations are clear. The sample was small, the experimental group had uniform baseline PBS scores, and the dataset lacked item-level PBS results. Without item scores, it is impossible to say whether the observed gain came mainly from standing tasks, reaching, turning, transfers, or one-leg stance. The protocol also needs better documentation of therapist assistance, ball size, adherence, child engagement, and home practice. These details should be included in a future protocol paper because they affect reproducibility.

A future study could improve the design in practical ways. First, PBS should be scored item by item and the total score calculated from the item sheet. Second, a blinded assessor should perform pre- and post-testing. Third, intervention fidelity should be documented using a session checklist. Fourth, caregiver-reported functional changes should be added, because a PBS gain is more meaningful when it corresponds to daily activities such as standing at a sink, reaching for toys, stepping onto a low stool, or moving from sitting to standing with less fear.

Suggested Exercise Photograph Section for Final Manuscript

The following photographs can be inserted in the final version of the manuscript after patient identity is protected and written consent for educational or publication use is confirmed.

Photograph 1: Kneel standing with therapist support. Photograph 2: Prone on physioball with bilateral hand reach-out. Photograph 3: Sitting on physioball with forward-backward balance challenge. Photograph 4: Sitting on physioball with side-to-side balance challenge. Photograph 5: Traditional quadruped or half-kneeling activity. Each figure should include a short caption describing the purpose of the activity, the support provided, and the intended progression.

[Insert Photograph 1: Kneel standing]	[Insert Photograph 2: Prone bilateral reach-out]

[Insert Photograph 3: Sitting on physioball]	[Insert Photograph 4: Side-to-side / forward-backward ball balance]

Clinical Recommendations

Use the physioball only when the child can be safely supported and the therapist can control the ball. The goal is a graded postural challenge, not instability for its own sake.

Begin with large, predictable support and short movement ranges. Progress only when the child shows calm participation, trunk correction, and the ability to recover posture without fear.

Use toys, small balls, flash cards, or visual targets to convert trunk control into a meaningful task. Children often respond better to reaching for an object than to being asked to activate the trunk.

Record PBS item-level scores in future work. Total scores are useful, but item-level patterns will show which balance components are improving and which remain difficult.

Conclusion

This protocol and outcome trend paper suggests that physioball-assisted core stability training can be integrated into pediatric physiotherapy for children with developmental delay as a structured adjunct to traditional exercise. The combined program produced larger average PBS gains than traditional exercise alone, but response variability was present and should guide clinical progression. The physioball is best understood as a graded tool for trunk control, righting reactions, reaching, and dynamic postural practice. Stronger evidence will require larger samples, item-level PBS reporting, assessor blinding, and detailed intervention fidelity records.

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Conflict of Interest

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

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