Impact Of Core Strengthening On Strenght And Mobility In Children With Cerebral Palsy

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Abstract

Cerebral palsy (CP) could be a cluster of disorders that have an effect on the event of movement and posture, inflicting activity limitation, and non progressive disturbances that occurred within the developing fetal or child brain[1]. A prominent clinical subtype of CP is spastic diplegia, characterized by hypertonia in the lower extremities, significant trunk weakness, reduced postural control[2]. Children with CP often experience significant limitations in performing basic motor tasks, such as running, stair climbing, walking on uneven surfaces, and achieving independent ambulation. These challenges stem from impaired motor control, spasticity, and musculoskeletal dysfunctions[3].

INTRODUCTION

BACKGROUND

Cerebral palsy is a static neurologic condition resulting from brain injury that occurs before cerebral development is complete. Because brain development continues during the first two years of life, cerebral palsy can result from brain injury occurring during the prenatal, perinatal, or postnatal periods [4,5]. Seventy to 80 percent of cerebral palsy cases are acquired prenatally and from largely unknown causes. Birth complications, including asphyxia, are currently estimated to account for about 6 percent of patients with congenital cerebral palsy[6]. Neonatal risk factors for cerebral palsy include birth after fewer than 32 weeks' gestation, birth weight of less than 5 lb, 8 oz (2,500 g), intrauterine growth retardation, intracranial hemorrhage, and trauma. In about 10 to 20 percent of patients, cerebral palsy is acquired postnatally, mainly because of brain damage from bacterial meningitis, viral encephalitis, hyperbilirubinemia, motor vehicle collisions, falls, or child abuse[6].

Cerebral Palsy is the most common cause of physical disability in children, with an estimated prevalence of 2–3 per 1000 live births. The prevalence is highest among children born before 28 weeks of gestation and lowest among those born after 36 weeks [4,5]. Among its various subtypes, Spastic Diplegic Cerebral Palsy is the most frequently observed clinical presentation, accounting for nearly 35% of cases. It is primarily characterized by spasticity affecting the lower limbs more than the upper limbs [5,6].

Functional limitation of children with CP may have various degrees due to loss of axial control with an imbalance of their movements [7]. Balance has been defined as the elements of postural control that allow a child to safely perform everyday tasks[8]. Poor balance control is one of the most contributing factors for poor gait and reaching movement because the maintenance of stability is critical to all movements[9] . Children with CP have defects in postural mechanisms, including righting and equilibrium reactions, antigravity mechanism, proximal stability, and postural fixation[10].

Core stability is defined as the ability to maintain position and movement of body core. Stability training involves the abdomen muscles and pelvic and shoulder muscles, which maintain postural alignment and allow movements of extremities. Postural control is mainly for motion and depends on these muscles for stability and endurance[11]. Components of core stability include strength, endurance, balance, and the related activity of the back, abdominal, and pelvic muscles[12],[13].Core stability training has been increasingly recommended as a therapeutic strategy to improve postural control and movement efficiency in individuals with neuromotor impairment. These exercises target the shoulder girdle and abdominal, pelvic, and spinal muscles, which are essential for providing a stable base from which the limbs can operate effectively while maintaining postural alignment[14]. Core stability encompasses components such as muscle strength, balance, endurance, and neuromuscular control of the trunk and pelvis[15],[16]. The core musculature functions as an integrated unit to stabilize the body during both static and dynamic tasks such as maintaining upright standing or coordinating limb movements[17].

In addition to supporting posture and movement, core stability plays a crucial role in minimizing the risk of injury and addressing muscular imbalance. It contributes to improved functional coordination and balance of both the upper and lower extremities by enhancing neuromuscular control across the kinetic chain[18]. Core stability exercises have been shown to facilitate physical performance by improving lumbar spine stabilization and activating the deep abdominal musculature, which are essential for maintaining trunk integrity during movement[19].

Procedure

1. Pre-intervention assessment:

Pre-intervention assessments were conducted using the Pediatric Balance Scale, GMFM and trunk impairment scale to establish baseline performance. Three baseline readings were recorded on separate days to ensure stability of the data.

2. Intervention protocol

Frequency & Duration: 4 sessions per week, 60 min per session

Session Structure: 30 min conventional physiotherapy, 30 min structured core stability training

i. Conventional Physiotherapy (30 min)

- Postural control in kneeling (figure 1)., stepping, single-leg stance.
- Stretching: hip flexors, adductors, hamstrings, quadriceps, calf muscles (20 s hold × 3–5 reps)
- Strengthening: hip abductors (side-lying), hip extension (prone hip extension), hamstrings (prone knee flexion), quadriceps (seated leg extension), abdominals (curl-ups, prone planks) (figure 2).

ii. Core Stability Training (30 min): Progressive levels (3 levels)

- Level 1 (Beginning)
  - ✧ Abdominal draw-in (20 reps)
  - ✧ Abdominal draw-in + double knee-to-chest (10–20 reps).
  - ✧ Supine trunk twists (10–20 reps)
- Level 2 (Intermediate)
  - ✧ Supine trunk bridging (3–5 reps) (figure 3).
  - ✧ Supine medicine ball twists (10–20 reps)
- Level 3 (Advanced)
  - ✧ Trunk bridging with back supported on physio-ball (hold 3–5 s × 10–20 reps
  - ✧ Prone bridging (plank) (3–5 reps). Rest Periods: 30–60 s between exercises

Repetition of Sequence: Full sequence repeated 3–5 times per session based on tolerance

3. Gait and Balance training Dosage

- Walking on variable surfaces
  - Walk on soft mats, foam pads, and firm ground
  - Dosage: 20 steps per surface × 3 sets
  - Progression: Increase surface difficulty and reduce support
- Transitioning between kneeling and standing (figure 4).
  - Practice moving from kneeling to standing
  - Dosage: 20 transitions × 3–5 sets
  - Progression: Increase repetitions or reduce assistive support
- Step training (ascending and descending)
  - Use a 15 cm step platform to practice ascending and descending
  - Dosage: 10 ascents + 10 descents per set × 3–5 sets
  - Progression: Increase step height or reduce assistance
- Dual-task standing and walking activities
  - Walk while performing cognitive tasks (holding an object, counting aloud)

- Dosage: 10 m of dual-task walking × 3 repetitions
- Progression: Add more complex cognitive tasks or increase distance

- Single-limb stance (eyes open and closed)
  - Balance on one leg with eyes open or closed, near stable support
  - Dosage: 10–20 seconds per leg × 3 repetitions
  - Progression: Increase duration or progress from eyes open to closed

4. Post-intervention protocol : After completing a 12 week core-strengthening intervention, the same outcome measures were reassessed.

Instrumentation

Pediatric Balance Scale (PBS)

A modified version of the Berg Balance Scale, the PBS consists of 14 functional balance tasks scored from 0 to 4, yielding a total score out of 56. It is specifically designed for children with mild to moderate motor disabilities and has demonstrated high inter-rater and test–retest reliability[29], as well as excellent face and content validity in children with spastic cerebral palsy[30].

Gross Motor Function Measure (GMFM)

The GMFM-88 was used to evaluate gross motor function, focusing on the standing dimension (Dimension D). Each item is scored on a four-point ordinal scale, and children were allowed up to three attempts per item. If the item was successfully performed on the first attempt, no further attempts were required. The overall score is expressed as a percentage based on the total score for that dimension[31].

Trunk Impairment scale

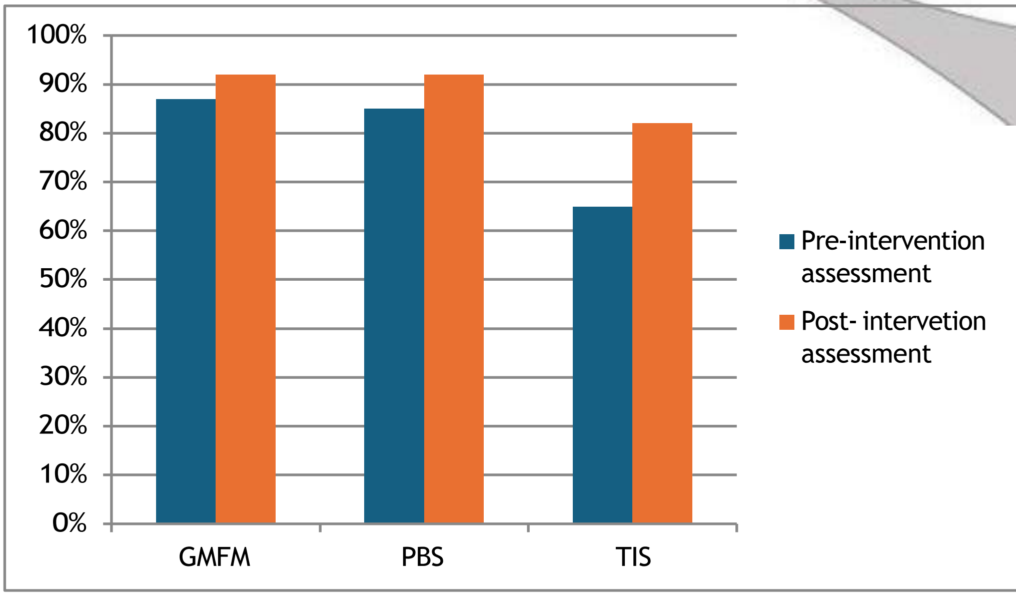
The Trunk Impairment Scale (TIS) was used to assess trunk control in sitting position. It consists of 17 items divided into three subscales: static sitting balance, dynamic sitting balance, and trunk coordination. Each item is scored on a scale, with a maximum total score of 23, where higher scores indicate better trunk control. The TIS has been shown to be a reliable and valid tool for evaluating trunk performance in individuals with neurological conditions, including cerebral palsy[32].

STATISTICAL ANALYSIS

OUTCOME MEASURES	PRE-INTERVENTION ASSESSMENT	POST-INTERVENTION ASSESSMENT
Gross motor function measure	**87 %**	**92 %**
Pediatric balance scale	**48/56**	**52/56**
Trunk Impairment scale 1. Static sitting balance 2. Dynamic sitting balance 3. Coordination **Total score**	1. 5/7 2. 7/10 3. 3/6 **15/23**	1. 6/7 2. 9/10 3. 4/6 **19/23**

RESULT

The structured 12-week core strengthening program produced measurable improvements across all outcome measures:



Gross Motor Function Measure (GMFM): Improved from 87% → 92%, reflecting enhanced functional mobility and motor performance.
Pediatric Balance Scale (PBS): Increased from 48/56 to 52/56, indicating better static and dynamic balance control.
Trunk Impairment Scale (TIS):
Static sitting balance: 5/7 to 6/7
Dynamic sitting balance: 7/10 to 9/10 Coordination: 3/6 to 4/6
Total score: 15/23 to 19/23
These findings demonstrate that core strengthening exercises contributed to improved trunk stability, balance, and overall functional mobility in the child with spastic diplegic cerebral palsy.

DISCUSSION

The results of this study support the hypothesis that core strengthening has a significant positive effect on balance and mobility in children with cerebral palsy. Improvements in GMFM, PBS, and TIS scores highlight the role of proximal stability in enhancing distal motor function. By targeting abdominal, pelvic, and spinal musculature, the intervention provided a stable base for limb movements, thereby improving gait efficiency and postural control. Zhou et al. (2024) emphasized that core stability exercises enhance lumbar spine stabilization and trunk integrity. Cabanas et al. (2017) reported improvements in dynamic balance and gait efficiency following trunk control training in neurologically impaired populations.

The modest yet clinically meaningful improvements observed in this single-patient case study reinforce the importance of incorporating structured core stability programs into pediatric physiotherapy practice. Even small gains in trunk control and balance can significantly impact independence in daily activities such as walking, stair climbing, and transitioning between postures.

Although this single-patient study demonstrated positive outcomes, future research should involve larger sample sizes to establish statistical significance and generalizability. Long-term follow-up is needed to determine whether improvements in balance and mobility are sustained over time. Comparative studies with other rehabilitation approaches, such as aquatic therapy or virtual reality-based training, may help identify the most effective strategies. Additionally, integrating advanced technologies like robotics or AI-based movement analysis could enhance precision, motivation, and functional independence in children with cerebral palsy.

CONCLUSION

In conclusion, this single-patient case study demonstrated that a structured core strengthening program produced measurable improvements in balance, trunk stability, and functional mobility in a child with spastic diplegic cerebral palsy. These findings highlight the clinical relevance of incorporating core stability exercises into pediatric physiotherapy practice, as even modest gains can significantly enhance independence in daily activities. While the results are promising, larger studies with long-term follow-up are needed to confirm generalizability. Future research should also investigate integration with advanced rehabilitation technologies to maximize functional outcomes and quality of life for children with cerebral palsy.

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