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Research Article

Comparative Effects of Vojta, Bobath, and Combined Therapy on Gait and Balance in Children with Spastic Diplegic Cerebral Palsy: A Randomized Controlled Trial

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Abstract

Spastic Diplegic Cerebral Palsy (SDCP), a subtype of Cerebral Palsy (CP) characterized by increased muscle tone predominantly affecting the lower limbs, leads to impairments in balance, gait, and functional mobility in children. This Randomized Controlled Trial was conducted at Al-Farabi Institute, Islamabad, Pakistan, to compare the effects of Vojta therapy (a reflex locomotion approach that stimulates automatic motor patterns), Bobath therapy (a Neuro-Developmental Treatment (NDT) focusing on postural control and functional movement), and their combined application on muscle tone, balance, and gait parameters. A total of 68 children (mean age 4.79 ± 1.74 years) with SDCP were randomly allocated into three groups: Vojta group (received reflex locomotion therapy), Bobath group (received NDT), and combined group (received both therapies in an integrated manner). Interventions were conducted for eight weeks (two sessions per week) along with daily parent-guided exercises. Outcome measures included the Modified Ashworth Scale (a clinical measure of spasticity), Gross Motor Function Classification System (a five-level scale classifying motor abilities), Pediatric Berg Balance Scale (a functional balance assessment tool), and spatiotemporal gait parameters measured using an electronic walkway system. All groups demonstrated significant improvements over time ($p < 0.05$); however, the combined group showed the greatest gains, with marked reductions in spasticity and improvements in balance and gait characteristics such as step length and stride length. These findings suggest that integrating Vojta and Bobath therapies may provide superior functional outcomes compared to either approach alone. Early implementation of combined therapy may enhance rehabilitation effectiveness in children with SDCP.

Keywords: Spastic diplegic cerebral palsy, Vojta therapy, Bobath therapy, Combined therapy, Gait, Balance, Rehabilitation.

1. Introduction

The term "Cerebral Palsy" (CP) refers to a collection of long-term impairments in posture and movement development that are linked to non-progressive abnormalities in the developing fetus or infant brain (Hallman-Cooper and Rocha Cabrero 2026). Children with CP often have motor impairments (abnormal tone, poor selective motor control, and atypical movement patterns), which are frequently accompanied by epilepsy, musculoskeletal problems, and disturbances of sensation, cognition, communication, perception, and behavior (Patel et al. 2020). These motor and associated impairments commonly transform into clinically important deficits in gait, balance, and functional mobility that limit participation and quality of life across the lifespan (Patel et al. 2020).

Table 1: Intervention Protocol for Vojta, Bobath, and Combined Therapy Groups

Group	Activity / Exercise	Time / Duration	Repetition / Sets
Vojta Therapy	Reflex Crawling (prone, head and limb positioning with pressure on specific zones)	15–50 sec activation per position	3 times
	Crouch Position (on bed edge, head turned, UL & LL flexion/extension, pressure applied)	15–50 sec activation per position	3 times
	3-Point Support & Reflex Creeping Exercise	15–50 sec activation	3 times
Bobath Neuro-Developmental Treatment (NDT)	Quadruped Imbalances (pushed from shoulders/pelvis)	30 sec break between sets	2 sets × 5 reps
	Kneeling Imbalances (pushed in all directions)	30 sec break	2 sets × 5 reps
	Servant Knight Position (pelvis stabilization, hip/knee/ankle flexion)	-	2 sets × 5 reps
	Kicking a Ball	1 set	10 reps
	Step Climbing	-	10 reps
	Marching in Place (alternate foot)	-	10 reps
Combined Vojta + Bobath	Reflex Crawling (Vojta)	15–50 sec activation	3 times
	Kneeling & Crouch Position (Vojta)	15–50 sec activation	3 times
	Quadruped & Kneeling Imbalances (Bobath)	30 sec break between sets	2 sets × 5 reps
	Servant Knight Position (Bobath)	-	2 sets × 5 reps
	Kicking a Ball	1 set	10 reps
	Step Climbing	-	10 reps
	Marching in Place (alternate foot)	-	10 reps

Spastic Diplegia Cerebral Palsy (SDCP), a common subtype of CP, primarily affects the lower limbs and is characterized by increased muscle tone and impaired coordination. A key feature of this condition is spasticity, defined as a velocity-dependent increase in muscle tone resulting from upper motor neuron lesions, which contributes to abnormal movement patterns and reduced functional efficiency. Global estimates show that the prevalence of CP is still significant; systematic investigations show that rates are greater in low and middle-income nations than in high-income ones, and overall birth-prevalence estimates have been about 2 per 1,000 live births (McIntyre et al. 2022). Regional data from Pakistan and surrounding areas show that spastic presentations, especially diplegia, are widespread in clinic-based and population studies and that the local burden can be larger than many high-income estimates (Naeem et al. 2025). When compared to their typically developing peers, children with SDCP typically show altered spatiotemporal gait parameters, which are quantitative measures describing the timing and distance characteristics of walking, such as step length, stride length, and cadence. These children often demonstrate reduced single-limb support time, shorter stride length, abnormal cadence, and increased base of support, along with impaired postural control. These changes are consistent across instrumented and clinical studies (Kim and Son 2014). Because gait and balance are essential to mobility, independence, and participation, rehabilitation strategies that reliably improve these domains are a priority for clinicians, families, and health systems, especially in situations when access to specialized care is restricted (McIntyre et al. 2022).

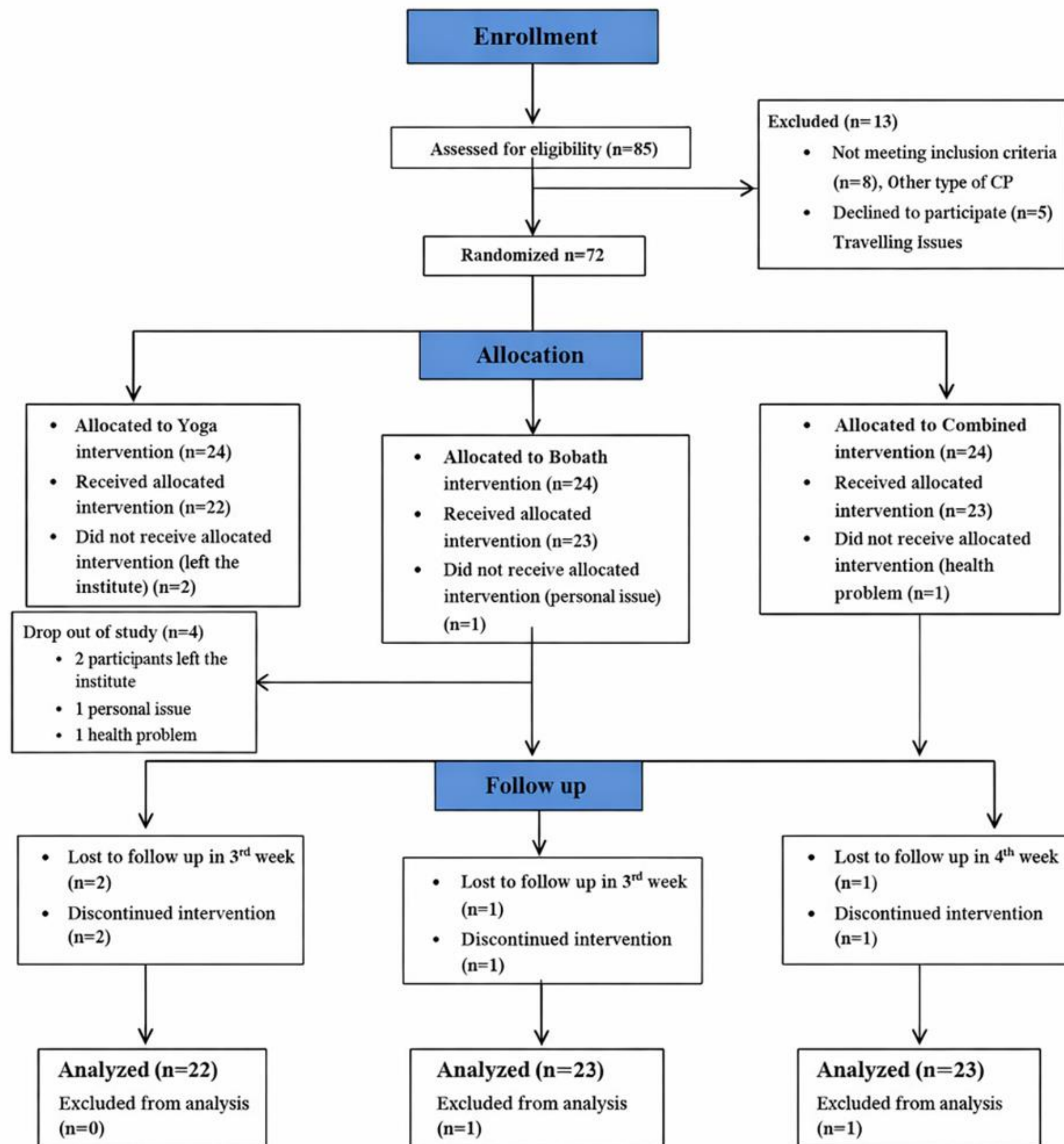

Figure 1 Consort Diagram

Two widely used physiotherapeutic approaches in paediatric neurorehabilitation are the Bobath Neuro-Developmental Treatment (NDT) concept and Vojta reflex locomotion, each grounded in different theoretical rationales. Bobath is defined as a therapeutic approach that emphasizes regulation of aberrant tone and the facilitation of task-specific, functional patterns via handling and postural training, while Vojta is a method that focuses on reflex locomotion zones to elicit automatic, centrally mediated motor patterns and enhance postural control (Pathak et al. 2021).

Even though Bobath/NDT has been used in clinical settings for a long time, systematic reviews show that there is little and conflicting high-quality data for its use in children with CP, and the Randomized Controlled Trials (RCT) that are now available are small and varied in terms of methodology and results (Zanon et al. ,

Table 2: Baseline Characteristics of Participants

Variable	Category / Group	Frequency (%) / Mean ± SD
Age (Years)	–	4.79 ± 1.74
Gender	Male	Vojta: 11 (50%)
		Bobath: 8 (34.8%)
		Combined: 10 (43.5%)
	Female	Vojta: 11 (50%)
		Bobath: 15 (65.2%)
		Combined: 13 (56.5%)
Education Level	Rehabilitation	33 (48.5%)
	Special	18 (26.5%)
	Formal	17 (25.0%)
Socioeconomic Status	Upper-Middle	20 (29.4%)
	Lower	48 (70.6%)
Treatment Groups	Vojta	22 (32.4%)
	Bobath	23 (33.8%)
	Combined	23 (33.8%)

2019). Similarly, although experimental and pilot studies suggest Vojta therapy can modify muscle activation patterns trunk control, and Gross Motor (GM) development, there are not many reliable randomized trials in the literature that look at how Vojta therapy affects gait and balance in ambulatory children with SDCP(Menéndez-Pardiñas et al. 2023).

There is clinical uncertainty regarding the best strategy for school-aged children with SDCP due to the small number of pilot studies and combined-therapy reports that have indicated potential additive benefits when Bobath and Vojta approaches are used together. However, these studies are limited by sample size, varied age groups (often infants), and diverse outcome measures (Menéndez-Pardiñas et al. 2023).

Evidence-based rehabilitation practice must be guided by direct, well-designed randomized comparisons of Bobath, Vojta, and their combined application in children with SDCP due to the functional significance of gait and balance as well as the heterogeneity and limitations of current evidence (Zanon et al. 2019). Accordingly, the present RCT was carried out to determine whether Vojta therapy, Bobath NDT, or a combined Vojta+Bobath therapy produces superior improvements in clinically-relevant gait and balance outcomes in children with SDCP, thereby providing clearer guidance for clinicians and policy-makers working in resource-constrained as well as well-resourced settings.

2. Material and Methods

A three-arm, parallel RCT, an experimental study design used to compare the effects of interventions by randomly allocating participants into groups, was conducted to compare the effects of Vojta therapy, Bobath NDT, and a combined Vojta+Bobath therapy on gait and balance in children with SDCP. The trial was conducted at Al-Farabi Institute, Islamabad, between August 2023 and February 2024, and was designed and reported in accordance with Consolidate Standard of Reporting Trial 2010 recommendations, which are standardized recommendations for reporting randomized trials to ensure transparency and methodological quality for parallel trials.

2.1. Participants

Children with Gross Motor Function Classification System (GMFCS), a five-level classification system that categorizes motor function in children with CP based on self-initiated movement abilities, levels II–III, and a clinical diagnosis of SDCP between the ages of 3 and 8 years, were recruited from outpatient physical therapy and pediatric neurology clinics. GMFCS Level II indicates children who can walk with limitations, while Level III represents children who walk using assistive mobility devices and the absence of botulinum toxin injections, a treatment used to reduce spasticity by temporarily weakening muscles or orthopaedic surgery within the preceding six months were included in the inclusion criteria. Progressive neurological problems, uncontrolled epilepsy, significant vision or hearing impairments that interfere with evaluation or any comorbidity that could compromise participation or gait were included in exclusion criteria. Age, sex, GMFCS level, spasticity, and the existence of comorbidities were all documented as baseline clinical and demographic data.

2.2. Sample Size and Randomization

Assuming a medium effect size (Cohen's d ≈ 0.6), 80% power, and α=0.05, the sample size was determined a priori to identify a clinically significant between-group difference in Pediatric Berg Balance Scale (PBBS) scores, yielding 72 participants (24 per group). Participants were randomly allocated in a 1:1:1 ratio into three groups: Vojta (reflex locomotion therapy), Bobath (NDT), and combined (integrated Vojta and Bobath therapy), using a computer-generated sequence prepared by an independent statistician. Allocation concealment was ensured through sequentially numbered, opaque, sealed envelopes (SNOSE), and opened after baseline assessment. Analysis was conducted using the intention-to-treat principle.

2.3. Blinding

Due to the nature of interventions, participants and therapists could not be blinded; however, outcome assessor blinding, a method used to reduce measurement bias by keeping assessors unaware of group allocation, was implemented. Assessors were instructed not to discuss allocation with participants or families, and assessor blinding procedures were documented.

2.4. Interventions

All interventions were delivered by experienced pediatric physiotherapists trained in the respective approaches, with fidelity ensured through manuals, structured protocols, and periodic supervision (Table 1, Figure 1). For eight weeks, each group took part in two 40-minute sessions every week.

Parents were instructed to perform daily exercises at home under supervision, and the exercises were tailored to each participant's capacity and focused on both lower limbs. Therapist help was given as needed, and the intervention adhered to the progression concept.

2.5. Vojta Therapy Group

Participants received reflex locomotion therapy, including stimulation of defined reflex zones and facilitation of automatic motor patterns in supine, prone, and lateral decubitus positions. Sessions were 40 minutes, twice weekly for eight weeks, emphasizing consistent stimulus location, pressure, and graded progression (Menéndez-Pardiñas et al. 2023, Sung and Ha 2020).

2.6. Bobath (NDT) Group

Therapy focused on the inhibition of abnormal tone and facilitation of normalized postural and movement patterns through hands-on handling, trunk control, weight-bearing, and task-oriented functional practice. Sessions were matched for frequency and duration with the Vojta group (Cabezas-López and Bernabéu-Brotóns 2022).

2.7. Combined Vojta+Bobath Group

Participants received integrated sessions comprising 20 minutes of Vojta stimulation followed by 20 minutes of Bobath-based

functional training, twice weekly for eight weeks. Both lower limbs were involved, and adaptations were provided based on the participant's ability. Parents were instructed to conduct daily home exercises under guidance (Parau et al. 2023).

2.8. Concomitant Care and Adherence

Routine medical care (e.g., anticonvulsants) was continued, while new physiotherapy programs were discouraged during the study period. Adherence to therapy sessions was monitored through attendance logs maintained by therapists. Home exercise compliance was tracked using parent-maintained daily exercise diaries, which were reviewed weekly by therapists. Periodic telephonic follow-ups were conducted to reinforce compliance and ensure consistency in intervention delivery.

2.9. Outcome Measures

The following assessment tools were utilized to evaluate spasticity, GM function, balance, and gait in children with SDCP. Outcomes were assessed at 0 week, 4th week, and after 8th week. All assessment tools used in this study were selected based on their established reliability and validity in pediatric neurological populations, ensuring methodological rigor.

2.10. Modified Ashworth Scale (MAS)

The MAS is a widely used clinical tool for measuring increased muscle tone, particularly in individuals with neurological conditions such as CP. To measure resistance during passive joint movement, it uses a six-point ordinal scale that goes from 0 (no rise in muscle tone) to 4 (affected part rigid in flexion or extension). The scale doesn't require any extra equipment and may be administered quickly. In children with SDCP, it demonstrates moderate inter-rater reliability and good intra-rater reliability, making it suitable for assessing muscle tone (Meseguer-Henarejos et al. 2018).

2.11. GMFCS

The GMFCS is a five-level system was used to categorize the GMF of children with CP based on their self-initiated movement abilities. Levels range from I (walks without limitation) to V (severely limited mobility). A validated and widely accepted classification system with strong reliability for categorizing functional mobility in children with CP (Morris and Bartlett 2004).

2.12. Key Gait Parameters

The following gait parameters were measured. Step Length: the distance between the initial contact points of two consecutive steps, Stride Length-the distance between the initial contact points of the same foot in consecutive steps, Cadence-the number of steps taken per minute, Velocity-the speed of walking, measured in meters per second, Base of Support-the lateral distance between the feet during walking, indicating base of support, and Foot Angle-the angle of the foot relative to the line of progression during the stance phase.

2.13. Data Analysis

SPSS version 25 was used for statistical analysis. Analysis of Variance (ANOVA)**,** a statistical test used to compare means across multiple groups, was used for normally distributed data. For repeated measures, ANOVA assessed between-group differences over time for normally distributed outcomes; mixed-effects models were used for unbalanced or missing data. Bonferroni post hoc testing, a statistical correction method used to control for multiple comparisons, was performed for pairwise group comparisons. Effect sizes (Cohen's d or partial η^2) and 95% confidence intervals were reported. Non-normal outcomes were analyzed using appropriate non-parametric methods. Missing data were handled according to the intention-to-treat concept, with sensitivity analysis via multiple imputations as needed.

2.14. Ethics and Trial Registration

The study protocol was approved by the review board of Riphah College of Rehabilitation and Allied Health Sciences, Islamabad, Riphah International University (Ref: RIPHAH/RCRS

Table 3: Between-Group Analysis (Mixed ANOVA) of Gait and Balance Variable

Variable	Effect	F-value	p-value	η²
MAS	Group	7.983	<0.05	0.197
	Time	84.269	<0.05	0.275
	Group × Time	10.140	<0.05	0.241
GMFCS	Group	4.519	>0.05	0.120
	Time	54.099	<0.05	0.628
	Group × Time	7.059	<0.05	0.181
PBBS	Group	9.807	<0.05	0.232
	Time	174.741	<0.05	0.729
	Group × Time	8.735	<0.05	0.212
Step Length (cm)	Group	4.820	>0.05	0.125
	Time	138.045	<0.05	0.680
	Group × Time	32.802	<0.05	0.423
Stride Length (cm)	Group	5.177	>0.05	0.128
	Time	98.424	<0.05	0.602
	Group × Time	21.965	<0.05	0.403
Cadence (steps per min)	Group	0.360	>0.05	0.011
	Time	12.526	<0.05	0.655
	Group × Time	19.711	<0.05	0.378
Velocity (m/s)	Group	0.897	>0.05	0.027
	Time	3.056	>0.05	0.045
	Group × Time	0.525	>0.05	0.016
Walking Base (cm)	Group	10.382	<0.05	0.242
	Time	150.05	<0.05	0.824
	Group × Time	6.528	<0.05	0.169
Foot angle (degrees)	Group	2.651	> 0.05	.075
	Time	123.834	< 0.05	.656
	Group × Time	10.199	< 0.05	.239

ISB/REC/MS-PT-01641), and written informed consent was obtained from parents/guardians. Child assent was obtained when developmentally appropriate. Ethical, cultural, and moral values were considered during data collection. The trial was prospectively registered with ClinicalTrials.gov (Registration No. [NCT06757101]). All procedures adhered to the Declaration of Helsinki.

3. Results

3.1. Participant Demographic and Clinical Characteristics

A total of 68 children with SDCP were included in this study. The mean age of participants was 4.79 ± 1.74 years. The Vojta group included an equal proportion of males and females (50% each), whereas the Bobath group had a higher proportion of females (65.2%), and the Combined group included 43.5% males and 56.5% females. Regarding educational enrollment, 48.5% of participants were in rehabilitation programs, 26.5% in special education, and 25% in formal schooling.

The majority (70.6%) belonged to a lower socioeconomic status.

Participants were evenly distributed across the three intervention groups: Vojta (32.4%), Bobath (33.8%), and Combined (33.8%), as shown in Table 2.

Table 4: Within-Group Analysis of Gait and Balance Variables (Mean ± SD)

Variable	Time Point	Vojta (Mean ± SD)	Bobath (Mean ± SD)	Combined (Mean ± SD)	F-value	p-value
MAS	Baseline	3.59 ± 0.796	3.22 ± 0.600	3.61 ± 0.891	1.874	>0.05
	4th Week	3.32 ± 0.945	2.52 ± 0.846	1.87 ± 0.968	13.941	<0.05
	8th Week	2.32 ± 1.323	1.83 ± 1.029	0.91 ± 1.041	8.901	<0.05
GMFCS	Baseline	2.68 ± 0.477	2.48 ± 0.511	2.61 ± 0.499	0.977	>0.05
	4th Week	2.50 ± 0.673	2.26 ± 0.689	1.74 ± 0.864	6.122	<0.05
	8th Week	2.14 ± 0.889	2.09 ± 0.793	1.39 ± 0.583	6.787	<0.05
PBBS	Baseline	20.95 ± 7.93	22.73 ± 8.01	27.73 ± 8.74	3.470	>0.05
	4th Week	23.00 ± 8.79	27.00 ± 9.76	35.78 ± 8.90	17.049	<0.05
	8th Week	28.45 ± 12.08	31.95 ± 10.52	42.60 ± 7.38	12.440	<0.05
Step Length	Baseline	24.32 ± 9.036	25.78 ± 9.439	29.74 ± 9.265	2.082	>0.05
	4th Week	24.41 ± 9.158	26.91 ± 10.045	33.13 ± 9.221	5.073	>0.05
	8th Week	25.86 ± 9.301	29.04 ± 10.451	36.91 ± 9.015	7.928	<0.05
Stride Length	Baseline	48.55 ± 18.16	51.52 ± 18.92	59.48 ± 18.53	2.104	>0.05
	4th Week	48.73 ± 18.40	53.78 ± 20.14	66.26 ± 18.44	5.097	>0.05
	8th Week	51.36 ± 18.82	57.17 ± 21.45	74.70 ± 16.76	9.154	<0.05
Cadence	Baseline	67.14 ± 20.39	70.04 ± 20.45	61.78 ± 12.30	1.233	>0.05
	4th Week	67.45 ± 20.52	71.74 ± 20.81	68.09 ± 14.12	0.347	>0.05
	8th Week	70.59 ± 21.13	75.87 ± 22.86	75.39 ± 17.74	0.445	>0.05
Velocity	Baseline	0.83 ± 0.463	0.68 ± 0.390	0.58 ± 0.181	2.832	>0.05
	4th Week	0.85 ± 0.465	1.06 ± 1.776	0.76 ± 0.264	0.482	>0.05
	8th Week	0.93 ± 0.473	1.13 ± 1.142	0.91 ± 0.232	0.630	>0.05
Walking Base	Baseline	19.82 ± 4.521	20.30 ± 4.646	26.52 ± 5.501	13.185	<0.05
	4th Week	19.32 ± 4.654	19.04 ± 4.216	23.74 ± 5.154	7.216	<0.05
	8th Week	16.23 ± 4.011	16.65 ± 3.927	21.26 ± 4.882	9.606	<0.05
Foot Angle	Baseline	19.77 ± 7.017	23.22 ± 6.557	25.43 ± 2.795	5.541	>0.05
	4th Week	19.27 ± 6.692	21.57 ± 5.558	21.91 ± 2.795	1.663	>0.05
	8th Week	17.77 ± 6.718	18.74 ± 5.471	20.26 ± 2.767	1.301	>0.05

3.2. Gender Distribution and Potential Confounding

The unequal gender distribution across groups (e.g., a higher proportion of females in the Bobath group) may act as a potential confounder; however, this occurred due to random allocation and participant availability. Baseline comparisons showed no significant differences in primary outcomes, indicating group comparability. Additionally, analysis of within- and between-group changes over time minimized the impact of gender imbalance. Future studies with larger samples are recommended for gender-based stratification.

3.3. Comparative Effects of Interventions on Spasticity, Balance, and Gait

Mixed ANOVA demonstrated a significant main effect of group, time, and group × time interactions for several gait and balance outcomes. For Spasticity, there were significant effects of group ($F = 7.983$, $p < 0.05$, $\eta^2 = 0.197$), time ($F = 84.269$, $p < 0.001$, $\eta^2 = 0.275$), and the group × time interaction ($F = 10.140$, $p < 0.001$, $\eta^2 = 0.241$), indicating differential reductions in spasticity across groups over time. For GMFCS, time ($F = 54.099$, $p < 0.001$, $\eta^2 = 0.628$) and group × time interaction ($F = 7.059$, $p < 0.05$, $\eta^2 = 0.181$) were significant, whereas the main effect of group was not ($F = 4.519$, $p > 0.05$, $\eta^2 = 0.120$). For Balance (PBBS), significant main effects were observed for group ($F = 9.807$, $p < 0.05$, η2 = 0.232), time ($F = 174.741$, $p < 0.001$, η2 Reh. Com.

04 (02) 2025, 81-85 0.729), and interaction ($F = 8.735$, $p < 0.001$, $\eta2 = 0.212$), reflecting improvements in postural control with differential gains among interventions. For Step Length, time ($F = 138.045$, $p < 0.001$, $\eta2 = 0.680$) and interaction ($F = 32.802$, $p < 0.001$, $\eta2 = 0.423$) were significant, while group alone was not ($F = 4.820$, $p > 0.05$). For Stride Length, significant effects of time ($F = 98.424$, $p < 0.001$, $\eta2 = 0.602$) and interaction ($F = 21.965$, $p < 0.001$, $\eta2 = 0.403$) were found. For Cadence, only time ($F = 12.526$, $p < 0.001$, $\eta2 = 0.655$) and interaction ($F = 19.711$, $p < 0.001$, $\eta2 = 0.378$) were significant. For Velocity, no significant main or interaction effects were detected. For Walking Base, significant effects were observed for group ($F = 10.382$, $p < 0.05$, $\eta2 = 0.242$), time ($F = 150.05$, $p < 0.001$, $\eta2 = 0.824$), and interaction ($F = 6.528$, $p < 0.05$, $\eta2 = 0.169$). For Foot Angle, time ($F = 123.834$, $p < 0.001$, $\eta2 = 0.656$) and interaction ($F = 10.199$, $p < 0.001$, $\eta2 = 0.239$) were significant, with no significant main effect of group ($F = 2.651$, $p > 0.05$) (Table 3).

3.3.1. Group Functional Improvements

Repeated measures ANOVA indicated progressive improvements within all groups, with the combined group showing significant changes over the 8-week intervention. For MAS, spasticity decreased significantly in all groups. In the combined group, MAS scores decreased from 3.61 ± 0.891 at baseline to 0.91 ± 1.041 at 8 weeks ($F = 8.901$, $p < 0.05$). For GMFCS improved, particularly in the combined group (2.61 ± 0.499 to 1.39 ± 0.583, $F = 6.787$, $p < 0.05$). For PBBS, balance improved significantly in all groups, with the Combined group showing the highest gains (baseline: 27.73 ± 8.74; 8th week: 42.60 ± 7.38, $F = 12.440$, $p < 0.05$). For Step and Stride Length, both parameters increased over time; the combined group step length improved from 29.74 ± 9.265 cm to 36.91 ± 9.015 cm ($F = 7.928$, $p < 0.05$) and stride length from 59.48 ± 18.53 cm to 74.70 ± 16.76 cm ($F = 9.154$, $p < 0.05$). For Cadence and Velocity, the combined group demonstrated meaningful improvements in cadence (61.78 ± 2.30 to 75.39 ± 17.74 steps/min) and velocity (0.58 ± 0.181 to 0.91 ± 0.232 m/s), although velocity changes were not statistically significant across groups. For Walking Base, significant reductions were observed, indicating improved gait stability (combined group: 26.52 ± 5.501 cm to 21.26 ± 4.882 cm, $F = 9.606$, $p < 0.05$). For Foot Angle, the combined group showed a significant decrease from 25.43 ± 2.795° to 20.26 ± 2.767° ($F = 1.301$, $p < 0.05$) (Table 4).

3.3.2. Post Hoc Analysis of Time- Dependent Improvements

Bonferroni-adjusted pairwise comparisons confirmed that the largest improvements occurred between baseline and 8th week, as well as between 4th and 8th weeks, particularly in the combined group. For MAS, significant reductions were observed in all groups from baseline to 8 weeks (combined MD = 3.892, $p < 0.05$). For GMFCS, the combined group showed significant improvement from baseline to 8 weeks (MD = 0.321, $p < 0.05$). For PBBS, balance scores increased significantly in all groups, with the combined group achieving the greatest improvement (MD = -6.826, $p < 0.05$). For Step and Stride Length, the combined group exhibited significant gains across all time points, whereas the Vojta and Bobath groups showed significant improvements mainly between 4th and 8th weeks. For Cadence, Velocity, and Walking Base, significant improvements were primarily observed in the combined group (Cadence MD = -7.304, Velocity MD = -0.157, Walking Base MD = 2.478, all $p < 0.05$). For Foot Angle, significant reductions were noted in the combined group (MD = 1.652, $p < 0.05$), reflecting improved lower limb alignment (Table 5).

4. Discussion

This study aimed to evaluate the efficacy of three therapeutic interventions—Vojta, Bobath, and a

Table 5: Post Hoc Pairwise Comparisons (Bonferroni) of Outcome Measures Across Time Points

Variable	Time Comparison	Vojta MD	p-value	Bobath MD	p-value	Combined MD	p-value
MAS	Baseline vs 4th week	0.273	>0.05	0.286	<0.05	1.739	<0.05
	4th week vs 8th week	1.273	<0.05	1.328	<0.05	2.696	<0.05
	Baseline vs 8th week	1.000	<0.05	1.391	<0.05	3.892	<0.05
GMFCS	Baseline vs 4th week	0.182	>0.05	0.197	>0.05	0.199	<0.05
	4th week vs 8th week	0.545	<0.05	0.391	>0.05	0.483	<0.05
	Baseline vs 8th week	0.346	<0.05	0.174	>0.05	0.321	<0.05
PBBS	Baseline vs 4th week	-2.045	>0.05	-4.261	<0.05	-8.043	<0.05
	4th week vs 8th week	-7.500	<0.05	-9.217	<0.05	-14.870	<0.05
	Baseline vs 8th week	-5.455	<0.05	-4.957	<0.05	-6.826	<0.05
Step Length	Baseline vs 4th week	-0.091	>0.05	-1.130	0.05	-3.391	<0.05
	4th week vs 8th week	-1.545	>0.05	-3.261	<0.05	-7.174	<0.05
	Baseline vs 8th week	-1.455	>0.05	-2.130	<0.05	-3.783	<0.05
Stride Length	Baseline vs 4th week	-0.182	>0.05	-2.261	0.05	-6.783	<0.05
	4th week vs 8th week	-2.818	>0.05	-5.652	<0.05	-15.217	<0.05
	Baseline vs 8th week	-2.636	>0.05	-3.391	>0.05	-8.435	<0.05
Cadence	Baseline vs 4th week	-0.318	>0.05	-1.696	<0.05	-6.304	<0.05
	4th week vs 8th week	-3.455	<0.05	-5.826	<0.05	-13.609	<0.05
	Baseline vs 8th week	-3.136	<0.05	-4.130	<0.05	-7.304	<0.05
Velocity	Baseline vs 4th week	-0.014	>0.05	-0.383	>0.05	-0.178	<0.05
	4th week vs 8th week	-0.095	<0.05	-0.452	>0.05	-0.335	<0.05
	Baseline vs 8th week	-0.082	<0.05	-0.070	>0.05	-0.157	<0.05
Walking Base	Baseline vs 4th week	0.500	>0.05	1.261	<0.05	2.783	<0.05
	4th week vs 8th week	3.591	<0.05	3.625	<0.05	5.261	<0.05
	Baseline vs 8th week	3.091	<0.05	2.391	<0.05	2.478	<0.05
Foot Angle	Baseline vs 4th week	0.500	>0.05	1.652	>0.05	3.522	<0.05
	4th week vs 8th week	2.000	<0.05	4.478	<0.05	5.174	<0.05
	Baseline vs 8th week	1.500	<0.05	2.826	<0.05	1.652	<0.05

combined approach—in improving gait, balance, and spasticity in children with SDCP. The results indicated that all interventions led to significant improvements over 8 weeks, with the combined group demonstrating the most significant gains across various outcomes. The significant reduction in spasticity observed in all groups aligns with findings from previous research. For instance, Menéndez-Pardiñas et al. (2023) reported that Vojta therapy improved the motor development of children with CP (Menéndez-Pardiñas et al. 2023b). Similarly, Tekin et al. (2018) discovered that Bobath therapy greatly enhanced children with CP's postural control and balance (Sorsdahl et al. 2008). According to Bartik et al. (2025), who reported improved balance and coordination in children with CP receiving combination therapy, the superior results of the combined method may be due to the synergistic effects of combining both therapies (Menéndez-Pardiñas et al. 2023a).

The significant improvements in balance observed in all groups are consistent with previous studies. Ungureanu (2022) reported that combining Bobath and Vojta therapies improved balance in children with CP (Ungureanu et al. 2022). El-Shamy et al. (2022) also reported that combined interventions improved balance and gait performance in children with CP (Emara et al. 2024).

The significant improvements in gait parameters in the combined group are supported by existing literature. Qian et al. (2025) reported that Vojta therapy improved gait in children with SDCP ("Exploring the Impact of Home-Based Vojta Therapy on Gait Performance in Individuals with Down syndrome: A Preliminary Feasibility Study - PMC," n.d.). Similarly, Suharto et al. (2024) reported that Bobath therapy enhanced balance in children with CP (Suharto et al. 2024). The superior outcomes of the combined approach may be due to the complementary effects of both therapies on motor control and coordination.

The significant changes in foot angle and walking base in the combined group are consistent with findings by Bartik et al. (2025), who reported improved coordination and proprioception in children with CP undergoing combined therapy (Bartik et al. 2025). The findings suggest that the combined therapy approach may offer superior benefits in improving spasticity, balance, and gait parameters in children with SDCP.

This study encourages combining Bobath and Vojta therapies to take advantage of their complementary advantages. To maximize rehabilitation results for kids with CP, clinicians should think about implementing this integrated strategy.

Despite the significant findings of this study, several limitations should be acknowledged.

The sample size was relatively small, which may limit the generalizability of the results. The study duration was limited to eight weeks, and therefore, the long-term effects of the interventions remain unknown.

Although standardized outcome measures were employed, certain assessments might have been impacted by possible inter-rater variability. Additionally, reliance on parent-reported adherence for home exercises may introduce reporting bias. An important practical consideration is the increased time commitment and cost associated with combined therapy. Since the combined approach involves integrating two therapeutic techniques within each session and may require additional therapist expertise, it could lead to a higher financial burden and scheduling challenges for families.

This may influence decision-making, particularly in low-resource settings where access to specialized rehabilitation services is already limited. Therefore, while combined therapy appears more effective, clinicians must balance clinical benefits with affordability and accessibility, tailoring interventions based on individual family circumstances. Overall, the findings support the use of a multimodal rehabilitation strategy to optimize functional outcomes in children with SDCP.

5. Conclusion

The present study concludes that in children with SDCP, both Vojta and Bobath therapies significantly improve spasticity, GMF, gait metrics, and balance.

However, the combined intervention consistently yielded the most noticeable and clinically significant improvements, underscoring the possible advantages of combining various therapy modalities. Significant improvements were noted in walking base, step, and stride length, postural control, and spasticity reduction, indicating improved functional mobility and gait efficiency. These results highlight the significance of a personalized, multimodal rehabilitation approach for improving motor outcomes in this population.

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Conflict of interest

The authors declare no conflict of interest.

Consent Forms

Each participant signed a consent form before participating in the research.

Authors Contributions

Asad Khan conceptualized and designed the study and performed data analysis. Unsa Zahoor was responsible for manuscript writing. Fuldisia Dilawar Butt contributed to data assembly. Hamza Ahmed Awan carried out data collection. Dr. Bilal Arshed Butt critically revised the manuscript. Atiezaz Khaliq assisted in data assembly. All authors reviewed and approved the final manuscript.

Data Availability

All the data relevant to this study are with the authors.

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