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Effect of modified scooter board therapy on trunk control and hip muscle activation in children with cerebral palsy – A pilot randomised control study☆

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ABSTRACT

Cerebral palsy (CP), with an incidence rate of 2.95, is one of the leading causes of disability in children. The excessive tone in several muscle groups causes significant movement deficits and secondary impairments, such as hip displacement, affecting quality of life. Although age-related functional positioning treatment is effective, it does not prevent secondary deficits. Literature recommends the use of task-based training with an emphasis on the functional elongation of these spastic muscle groups. Thus, a therapy that is engaging, parent-inclusive, and addresses hip-related deficits is needed. Hence, this study aimed to develop and evaluate a therapy targeting adductor overactivity and trunk control. Modified Scooter Board Therapy (MSBT) is an intervention that uses a specially designed scooter board device, allowing children to propel themselves forward while positioned prone with hip abduction and neutral hip rotation. A convenient sample of eight children with CP were assigned to either the MSBT or conventional exercise group. The intervention lasted eight weeks, and electromyographic (EMG) recordings at rest and during volitional activity were obtained at baseline and after eight weeks. Non-parametric statistical analysis, with a significance level of $p < 0.05$, showed no statistically significant differences between the groups at the end of the eight weeks. However, volitional hip adductor activity significantly changed in the MSBT group, indicated by a reduction in mean motor unit potential at rest. Additionally, parents preferred MSBT for its ease of use. Thus, MSBT appears to be a clinically promising intervention to reduce adductor hypertonicity and improve active control, highlighting the importance of prone positioning with active elongation for better motor function.

1. Introduction

The National Family Health Survey (NFHS) 2015–16 reported that 79 % of childbirths take place in health facilities; however, many unsupervised obstetric deliveries are still prevalent in India (Chauhan et al., 2019). This resulted in a pooled prevalence rate of CP of 2.95 (95 % CI 2.03–3.88) per 1000 children, with prevalences of 1.83 and 2.29 in rural and urban settings, respectively (Chauhan et al., 2019; Census tables, 2022). In Karnataka, according to the 2011 census, 4.94 % of the total population has some form of disability, of which 4.55 % are children and 4.8 % have movement disabilities (Census tables, 2022).

All types of children with CP have positive signs (e.g., altered muscle tone and pathological reflexes) and negative signs (e.g., loss of motor control, loss of cocontraction, reciprocal inhibition, delayed termination of motor unit activity, prolonged muscle fibre activation and restricted range of motion) (Tranchida and Van Heest, 2020; Rassafiani and Sahaf, 2011). These changes lead to abnormal movement patterns, impaired motor function and altered postural control, thereby affecting the ability to sit/walk (33 %). Many show limb scissoring with knee flexion, leading

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to hip displacement (33 %), hence influencing quality of life, especially the physical well-being and independent living of children with CP (Kallem Seyyar et al., 2019; Novak et al., 2012; Gilson et al., 2014).

Motor development in early years follows the cephalon caudal direction, and the duration spent in the prone position is the major contributing factor to identifying the trajectory of development. Many intervention strategies employed in CP obtain functional movements through age-based functional positions (Camacho et al., 2016; Judith et al., 2016). Positional seating is among these functional positions and may negatively influence the trunk and lower extremity muscles, leading to poor postural control and the development of secondary complications such as hip pathologies. In addition, hip pathologies are associated with the abnormal activation of muscles, namely, adductors, which are excessively activated in the spastic CP (White and Panjabi, 1990; Oatis, 2009; Larkin-Kaiser et al., 2019; Mathewson and Lieber, 2015).

The literature recommends the use of segmental training of the trunk and the incorporation of exercises that are based on the principles of task-based learning (Curtis et al., 2015). The incorporation of functional stretching has been shown to be effective in reducing the level of spasticity in children with CP (Elshafey et al., 2014). Considering the recommendations of the ICF framework, an intervention that incorporates function, family, and fun-filled physical activity will be beneficial for improving the inclusiveness of children with CP (Ryan et al., 2017).

Thus, the present feasibility study aimed to develop an innovative, cost-effective and engaging therapy targeting adductor muscle overactivity and trunk control.

2. Materials and methods

The parallel group randomised controlled pilot and feasibility study was approved by the Scientific Review Committee and Institutional Ethics Committee of KMC, Mangalore, MAHE (IECKMCMLR-10/2022/414). Furthermore, the trial was registered under the Clinical Trial Registry of India with reference no. CTRI/2023/07/055707.

2.1. Design and development of the modified Scooter Board

Commercially, there exists several designs for scooter boards, with one notable example being the Tumbleform 2® Jett Mobile. Despite the device facilitating a prone position, there remains a significant limitation regarding the complete unsupported state of the trunk on the scooter board; moreover, the range of hip abduction is restricted to values below the functional range, while the intermediate joints of the lower extremities retain the ability to be mobilized. Furthermore, the vertical distance from the floor to the upper surface of the Tumbleform 2® is considerably limited and fails to adequately account for the weight-bearing capabilities of the upper extremities, alongside the complete physiological range of the intermediate joints. The most pronounced drawback of this device is its status as an imported product, which incurs substantial procurement costs, and it is noteworthy that the scooter board was originally designed to enhance sensory-motor development in children experiencing sensory dysfunctions (Smith et al., 2015; Tumbleform, 2025). Based on the clinical expertise of professors working in the field of paediatric rehabilitation, the initial concept of modifying the existing scooter board was initiated. The prototype scooter board was designed in the shape of a triangle and was made of plywood mounted on four 360* castor wheels. The testing was performed by positioning the typical child prone by weight bearing on hands, and parameters of the scooter board, such as height from ground, comfort, range of hip abduction, and placement of leg straps, were determined. The second prototype was developed with the necessary modifications and was prescribed to a child with CP who confirmed their consent to test the device. The feedback from the family was obtained, and further adjustments in the overall weight, locking of castor, and padding of the board were made, and the final product was developed (Fig. 1).

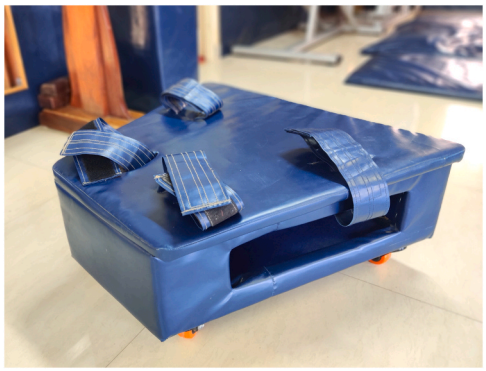

Fig. 1. Modified Scooter Board.

2.2. Sample

A convenience sample size of 8 was considered following simple randomisation with a 1:1 allocation ratio, using a random sequence generated via www.sealedenvelop.com, which included 4 children each in the MSBT and conventional groups. The children were recruited from the Neurosensory Development Unit (NSDU), KMC Bejai. The parents of the identified children were approached and explained the study, and informed assent and consent were obtained.

2.2.1. Inclusion criteria

Medically diagnosed children with CP who are between three and twelve years old and have no complete active control while sitting and who are in GMFCS levels III-V with Modified Ashworth scale grades below 4 and able to follow simple verbal commands were included.

2.2.2. Exclusion criteria

Children who had any associated genetic conditions, fixed skeletal deformities or contractures of the upper and lower extremities, or who were on oral antispastic medications and intramuscular injections in the past three months were excluded.

2.3. Intervention

The MSBT group received 7 days a week of (three days in the clinic and 4 days at home) scooter board therapy employed in two modules, static and dynamic, along with conventional therapy. The conventional group received only conventional exercises targeting the hip and trunk muscles, joint mobility, muscle range of motion and muscle strength. The total duration of therapy lasted for 1–4 h per session and lasted for 8 weeks. The intervention was provided by an independent, qualified physical therapist who was blinded to the study objectives and was not associated with the study methodology.

2.3.1. MSBT Intervention

The child was placed in a prone position on the scooter board such that the line joining the ASIS was placed exactly at the narrow anterior end. Both extremities were secured with removable Velcro® straps. The child maintained this prone position by weight bearing on the upper extremity (Fig. 2).

The modified scooter board therapy program was divided into two modules and involved practicing on the Modified Scooter Board in addition to conventional exercises (Tables 1–4).

Module I – Static control, under which the child learns to maintain the static position on the Modified Scooter board (MSB). This module was for one–two weeks; as the child mastered this module (noted by a reduced anxiety level and ability to maintain the prone position for a

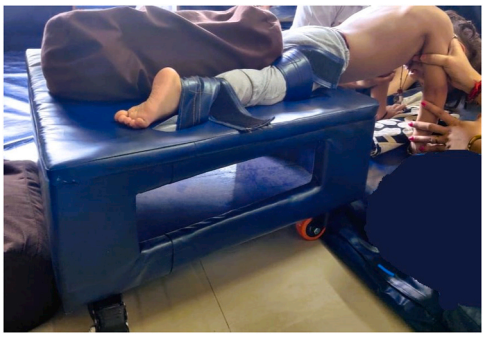

Fig. 2. Child using Modified scooter board.

minimum duration of 5 min), exercise progressed to Module II.

Module II – Dynamic control, for the remaining seven-week-old child, followed this module. In this module, the child was allowed to propel the scooter board using their upper extremities, initially slowly and progressing to self-paced propulsion by the child. Further progression was performed by positioning the child anteriorly such that pelvis contact on the scooter board was gradually reduced to add more weight to the upper extremities and to demand greater activity if the child excels in self-propelling. Each parent was adequately explained to position the child based on the protocol and was given a diary to record the day and duration for which therapy is practiced and was asked to record the treatment using a mobile camera; and the same was verified during the follow-ups to ensure compliance and technical specification of training.

2.3.2. *Conventional exercise*

Conventional exercises (Table 4) based on the principles of Bobath and NDT are widely practiced therapy regimens. These exercises focus mainly on facilitating the ability to move against gravity efficiently. The exercises incorporate the ability to have functional muscle range of motion, joint mobility, muscle strength, joint alignment, synergistic activity and adequate weight shifting (Hypes et al., 1994).

2.4. *Outcome assessment*

The assessment was performed by the primary investigator, who was blinded to the allocation into the MSBT or conventional group. The demographic details and EMG data of the muscles of the trunk and hip and the SATCO were obtained at baseline and at the end of eight weeks. The EMG recording was performed via the Data LITE wireless sensor system via biometrics. The Data LITE wireless EMG sensors (LE230 wireless EMG), with bandwidths of 20–480 Hz by a 1000 gain amplifier, were used to acquire the muscle signals. The parents were briefly informed about the surface EMG, what it measures, and what is expected from the child during the assessment. The analysis was performed in a quiet and non-distracting environment with the child in a supine, prone, side-lying or sitting position based on the muscles being analysed, ensuring comfort. The area of electrode placement was exposed, and the skin was prepared by cleaning the area with an alcohol-dipped cotton swab. Wireless EMG sensor LE230 was placed on the skin on the basis of the SENIAM guidelines, and two-sided medical-grade adhesive stickers were used. The motor unit potential (MUP) was obtained from trunk flexors and extensors, Iliopsoas, Gluteus maximus, Gluteus Medius and Adductors. The active signals were subsequently monitored, calibrated and verified by observing appropriate baseline signals and increasing the signal amplitude during voluntary movement. The MUP was recorded under the following conditions: (a) amplitude of the MUP at rest and (b) amplitude of the MUP following voluntary contraction.

3. Results

The data obtained were coded and entered into the statistical software Jamovi 2.21, and descriptive and analytical statistics were used to test the dataset. The demographic characteristics are presented in Table 1. The children included were in the age range of 4–13 years. Compared with those in the conventional therapy group, 75 % of the MSBT group children with a diagnosis of diplegia had quadriplegia (50 %). The obtained data were tested for normality.

3.1. *Feasibility*

3.1.1. *Eligibility, acceptance and adherence*

Among the sixteen children screened for eligibility, only 8 could be included in the study upon verification of the inclusion and exclusion criteria. Six children had significant cognitive impairment and could not follow simple verbal commands, whereas two did not consent to participate because of frequent visits for the assessment (Fig. 3). However, the included children and their parents readily participated in the intervention program, which was denoted by 100 % of the children being evaluated after the 8-week intervention program. Although the children were able to visit the NSDU while the practice pattern was evaluated, three of the parents did not adequately adhere to the duration of the intervention, which was noted on the therapy diary and from verbal feedback collected during the follow up visits.

Table 1
Demographic details of the children included categorised based on GMFCS levels.

Variable		Experimental (N = 4)	Control (N = 4)	Total (N = 8)	p value
Age	Mean (SD)	8.8 (3.0)	6.8 (2.2)	7.8 (2.7)	0.3231[a]
	Range	6.0–13.0	4.0–9.0	4.0–13.0	
Weight	Mean (SD)	14.5 (2.6)	14.2 (2.1)	14.4 (2.2)	0.8861[b]
	Range	12.0–18.0	12.0–17.0	12.0–18.0	
Gender	Male	2.0 (50.0 %)	3.0 (75.0 %)	5.0 (62.5 %)	0.4652[a]
	Female	2.0 (50.0 %)	1.0 (25.0 %)	3.0 (37.5 %)	
Type of CP	Diplegia	3.0 (75.0 %)	1.0 (25.0 %)	4.0 (50.0 %)	0.3112[b]
	Quadriplegia	1.0 (25.0 %)	2.0 (50.0 %)	3.0 (37.5 %)	
	Paraplegia	0.0 (0.0 %)	1.0 (25.0 %)	1.0 (12.5 %)	
MAS[@]	1	0.0 (0.0 %)	1.0 (25.0 %)	1.0 (12.5 %)	
	2	4.0 (100.0 %)	0.0 (0.0 %)	4.0 (50.0 %)	-
	3	0.0 (0.0 %)	3.0 (75.0 %)	3.0 (37.5 %)	
GMFCS[c] level	III	4.0 (100.0 %)	1.0 (25.0 %)	5.0 (62.5 %)	0.0282[b]
	IV	0.0 (0.0 %)	3.0 (75.0 %)	3.0 (37.5 %)	
Ambulatory	Yes	3.0 (75.0 %)	0.0 (0.0 %)	3.0 (37.5 %)	0.0282[b]
	No	1.0 (25.0 %)	4.0 (100.0 %)	5.0 (62.5 %)	

[a] Linear Model ANOVA;
[b] Pearson's chi-square test; MAS, modified Ashworth scale;
[c] Gross Motor Function Classification System.

Table 2
Differences in motor unit potential during rest and activity between the MSBT and conventional groups at baseline.

	Group	N	Mean	SD	Mean Difference	p
RHFR-p	Experimental	4	0.04175	0.05702	0.01175	0.724
	Control	4	0.03	0.02814		
RHFA-p	Experimental	4	0.0355	0.0148	−0.01975	0.303
	Control	4	0.05525	0.03177		
RHER-p	Experimental	4	0.025	0.0335	0.01625	0.381
	Control	4	0.00875	0.00759		
RHEA-p	Experimental	4	0.01775	0.01891	−0.003	0.825
	Control	4	0.02075	0.01776		
RHADR-p	Experimental	4	0.008	0.00627	0.00325	0.363
	Control	4	0.00475	0.00206		
RHADA-p	Experimental	4	0.0165	0.0233	−0.07325	0.364
	Control	4	0.08975	0.14718		
RHABR-p	Experimental	4	0.0045	0.00574	−0.00175	0.654
	Control	4	0.00625	0.00472		
RHABA-p	Experimental	4	0.0155	0.0106	−0.003	0.732
	Control	4	0.0185	0.01297		
RTFR-p	Experimental	4	0.012	0.00872	−0.0225	0.111
	Control	4	0.0345	0.02243		
RTFA-p	Experimental	4	0.0175	0.011	−0.00575	0.601
	Control	4	0.02325	0.01767		
RTE1R-p	Experimental	4	0.02025	0.01193	−0.05425	0.407
	Control	4	0.0745	0.12111		
RTE1A-p	Experimental	4	0.0455	0.0275	0.00325	0.881
	Control	4	0.04225	0.03102		
RTE2R-p	Experimental	4	0.0185	0.01401	−0.038	0.447
	Control	4	0.0565	0.09234		
RTE2A-p	Experimental	4	0.02775	0.02871	−0.073	0.269
	Control	4	0.10075	0.1163		
LHFR-p	Experimental	4	0.0265	0.03266	0.0025	0.897
	Control	4	0.024	0.01715		
LHFA-p	Experimental	4	0.041	0.03334	−0.04625	0.454
	Control	4	0.08725	0.11064		
LHER-p	Experimental	4	0.00875	0.01223	−0.002	0.814
	Control	4	0.01075	0.01078		
LHEA-p	Experimental	4	0.02425	0.01176	0.0055	0.573
	Control	4	0.01875	0.01422		
LHADR-p	Experimental	4	0.0085	0.00794	0.003	0.488
	Control	4	0.0055	0.00173		
LHADA-p	Experimental	4	0.011	0.00927	−0.033	0.159
	Control	4	0.044	0.03994		
LHABR-p	Experimental	4	0.0085	0.01308	−0.007	0.404
	Control	4	0.0155	0.0085		
LHABA-p	Experimental	4	0.0175	0.01936	−0.03125	0.144
	Control	4	0.04875	0.03175		
LTFR-p	Experimental	4	0.01125	0.0075	−0.06175	0.214
	Control	4	0.073	0.08849		
LTFA-p	Experimental	4	0.014	0.00702	−0.0205	0.204
	Control	4	0.0345	0.02787		
LTE1R-p	Experimental	4	0.02225	0.0131	−0.01875	0.288
	Control	4	0.041	0.02942		
LTE1A-p	Experimental	4	0.03825	0.01638	−0.0035	0.77
	Control	4	0.04175	0.01592		
LTE2R-p	Experimental	4	0.024	0.00648	0.0125	0.013
	Control	4	0.0115	0.003		
LTE2A-p	Experimental	4	0.0425	0.01457	0.0165	0.103
	Control	4	0.026	0.00913		

*Independent sample t test $p < 0.05$; N, number of samples; SD, Standard Deviation; HFR, Hip flexor at rest; HFA, Hip flexor active; HER, Hip extensor at rest; HEA, Hip extensor active; HABR, Hip abductor at rest; HABA, Hip abductor active; HADR, Hip adductor at rest; HADA, Hip adductor active; TFR, Trunk flexor at rest; TFA, Trunk flexor active; TE1R, Erector spinae at rest, TE1A, Erector spinae active; TE2R, Multifidi at rest; TE2A, Multifidi active; R, Right; L, Left; 2, post 8 weeks.

3.1.2. *Feasibility of intervention*

The MSBT intervention was administered over an 8-week period. It involved three outpatient sessions per week, with the remaining days dedicated to practising the therapy at the children's homes. The parents of the participating children found the intervention protocol convenient to implement, and the children appeared comfortable performing the exercises on the modified scooter board. Additionally, parents observed that the MSBT was straightforward to administer. The therapy required the children to propel themselves forward using their arms while maintaining their lower extremities within functional hip joint ranges, with the parents' role being limited to motivating and guiding the children. However, as the therapy was practiced at home three days a week, feedback from parents revealed that some parents found it challenging to accurately report and adhere to the recommended practice duration of four hours per day. Overall, the proposed MSBT protocol was feasible to implement, and no alteration in the intended therapy regime was needed.

3.1.3. *Practicality of outcome measures*

This pilot study assessed muscle activity via surface EMG sensors and trunk control via SATCO. The intended outcome measures were successfully evaluated according to the protocol. However, in two children with an MAS score of 2, performing the intended active movements was challenging, although the muscular effort, as indicated by MUP, was adequately recorded. Additionally, the assumed 30-minute duration for outcome measure assessment extended to approximately one hour. This extension included the time needed to ensure that the children understood the instructions, which presented a challenge for the assessors. Despite these difficulties, the intended outcome assessments were successfully completed.

3.1.4. *Muscle activity change*

The MUP signal was captured by a DG2 wireless Bluetooth dongle and interfaced with Biometrics DataLOG/DataLITE PC software version 10.13. The signal amplitude was set at 0–10 mV, and a low-frequency filter (high pass) and high-frequency filter (low pass) were set at 10 Hz to 500 Hz, with a frequency sampling rate (sampling frequency) of 5 kHz. The MUP was rectified and smoothed via a 50 ms root mean square (RMS) moving window to obtain the absolute value of the MUP signal.

Table 2 summarises the MU potential at rest and during voluntary action at baseline (Figs. 4 and 5). Independent sample t tests revealed no significant differences in the MUP between the MSBT and conventional groups at baseline. Table 3 summarises the MUP at rest and during voluntary action at the end of 8 weeks, which did not meet the homogeneity assumption of the t test; thus, the Mann—Whitney *U* test was employed (Figs. 6 and 7). The test results revealed no significant differences between the MSBT and conventional groups; however, hip abductor volitional activity and trunk flexor volitional activity were nearly significant ($p = 0.05$). In addition, the mean difference in the hip adductor muscle motor unit potential at rest was significantly lower than that in the other included muscles. These findings indicate a reduction in the tone of the adductor muscle in the MSBT group.

4. Discussion

This study was conducted to assess the feasibility and applicability of MSBT in addition to conventional therapy in children with CP who are at GMFM levels III, IV and V. The intended intervention protocol was found to be feasible for implementation in children with CP; however, the patient diary aided in identifying the lack of adherence to the exercise duration while practicing at their residence, the patient diary was evaluated for the adequate recording of the exercise by parents and report the same during the visit to the NSDU (van Berge Henegouwen et al., 1999).

The study evaluated the MUP via wireless surface EMG sensors placed on the SENIAM guidelines. The evaluation was thought to be conducted with all the sensors placed bilaterally and recorded at once, but the technique of recording was not feasible, as often the child experienced difficulty moving both limbs on command. Thus, the evaluation was changed to an individual assessment of the muscles in series, one following the other. However, the former method of evaluation

Table 3
Differences in motor unit potential during rest and activity between the MSBT group and the conventional group at the end of 8 weeks.

	Group	N	Mean	SD	Mean Difference	P*
RHFR−2	Experimental	4	0.0065	0.00451	−0.013	0.2
	Control	4	0.02425	0.02014		
RHFA−2	Experimental	4	0.7735	1.48039	−0.007	0.886
	Control	4	0.055	0.02782		
RHER−2	Experimental	4	0.00375	0.00377	−0.00786	0.301
	Control	4	0.01225	0.01044		
RHEA−2	Experimental	4	0.0125	0.00929	−0.008	0.486
	Control	4	0.02175	0.01276		
RHADR−2	Experimental	4	0.003	0.00245	−0.00114	0.381
	Control	4	0.0045	0.00238		
RHADA−2	Experimental	4	0.01725	0.01429	−0.0065	0.343
	Control	4	0.08625	0.13621		
RHABR−2	Experimental	4	0.003	0.00283	−0.00204	0.297
	Control	4	0.00775	0.00763		
RHABA−2	Experimental	4	0.00725	0.00562	−0.01252	0.055#
	Control	4	0.021	0.00931		
RTFR−2	Experimental	4	0.02175	0.01201	−0.0095	0.663
	Control	4	0.02775	0.0096		
RTFA−2	Experimental	4	0.03275	0.01103	0.0195	0.057#
	Control	4	0.01475	0.00629		
RTE1R−2	Experimental	4	0.00875	0.00506	−0.00695	0.381
	Control	4	0.03375	0.04255		
RTE1A−2	Experimental	4	0.023	0.01055	−0.007	0.343
	Control	4	0.041	0.03119		
RTE2R−2	Experimental	4	0.0055	0.00387	−0.00889	0.108
	Control	4	0.0535	0.08444		
RTE2A−2	Experimental	4	0.0275	0.02631	−0.032	0.343
	Control	4	0.09375	0.1072		
LHFR−2	Experimental	4	0.0155	0.02442	−0.00519	0.384
	Control	4	0.02125	0.01644		
LHFA−2	Experimental	4	0.4735	0.87924	−0.00296	0.885
	Control	4	0.08725	0.10804		
LHER−2	Experimental	4	0.00425	0.00189	−0.00446	0.557
	Control	4	0.00775	0.00618		
LHEA−2	Experimental	4	0.01075	0.00427	−0.01449	0.11
	Control	4	0.0255	0.01446		
LHADR−2	Experimental	4	0.004	0.00424	−0.00205	0.559
	Control	4	0.005	0.00183		
LHADA−2	Experimental	4	0.0225	0.02142	−0.00801	0.468
	Control	4	0.04725	0.04983		
LHABR−2	Experimental	4	0.003	0.00245	−0.00508	0.11
	Control	4	0.00975	0.00727		
LHABA−2	Experimental	4	0.01325	0.0113	−0.0215	0.486
	Control	4	0.0405	0.03453		
LTFR−2	Experimental	4	0.025	0.01364	−0.0115	0.886
	Control	4	0.0395	0.02852		
LTFA−2	Experimental	4	0.0225	0.007	−0.00101	0.657
	Control	4	0.035	0.03		
LTE1R−2	Experimental	4	0.01475	0.00287	−0.01308	0.059
	Control	4	0.039	0.03117		
LTE1A−2	Experimental	4	0.0735	0.06183	0.0065	0.486
	Control	4	0.04075	0.01279		
LTE2R−2	Experimental	4	0.08	0.14553	−0.00287	1
	Control	4	0.01175	0.0033		
LTE2A−2	Experimental	4	0.14475	0.23006	0.0145	0.486
	Control	4	0.02525	0.00929		

* Mann—Whitney *U* test $p < 0.05$; N, number of samples; SD, Standard Deviation, #, Near to significant difference, MUP in micro volt; HFR, Hip flexor at rest; HFA, Hip flexor active; HER, Hip extensor at rest; HEA, Hip extensor active; HABR, Hip abductor at rest; HABA, Hip abductor active; HADR, Hip adductor at rest; HADA, Hip adductor active; TFR, Trunk flexor at rest; TFA, Trunk flexor active; TE1R, Erector spinae at rest, TE1A, Erector spinae active; TE2R, Multifidi at rest; TE2A, Multifidi active; R, Right; L, Left; 2, post 8 weeks.

would have reduced the overall duration of EMG assessment, and appropriate MUP generation may have been hampered. The trunk control assessment performed by the SATCO was feasible for evaluation, and the results indicate the prospect of MSBT intervention causing changes in trunk control over a short duration.

The study revealed a mild to moderate effect of the MSBT program in addition to conventional therapy in reducing the hypertonicity of muscles around the hip joint. The study was conducted on a sample of eight children with CP who had significant sitting control limitations in addition to mobility in lower functional positions. Overall, the muscle MUPs were different across the muscles between the MSBT and conventional therapy groups, although the difference was not statistically significant. The mean differences in the MUPs were significant across major muscles, such as the adductor of the hip, the abductor of the hip, the trunk flexors and, to a slight extent, the trunk extensors. The relative difference in MUP may be indicative of reduced hypertonicity in these

Table 4
Description of intervention Modified scooter board therapy and Conventional exercise program (Karnad et al., 2025).

Intervention / Parameters	Modified scooter board therapy	Conventional exercise
Position of child	Prone Positioning on MSB a. The line connecting the anterior superior iliac spines (ASIS) will be aligned with the front edge of the MSB. b. Both lower limbs will be positioned in abduction and secured using removable Velcro® straps.	The child's position - prone, supine, or sitting - will be selected based on the specific exercise being performed. Activities will begin on the floor and gradually advance to being performed on a therapy ball.
Exercise	**Module I**: The child will hold a prone position on the MSB. This phase will continue for 1–2 weeks until the child is able to maintain the static posture confidently. **Module II:** Once the static position is mastered, the child will begin propelling forward on the scooter board using their upper limbs.	Conventional exercises follow the principles of Bobath and Neurodevelopmental Therapy (NDT), which are well-established and commonly used therapeutic approaches. These exercises focus on improving muscle range of motion, joint mobility, and muscle strength, specifically targeting the trunk and lower limbs.
Specification	Total Therapy Duration: The therapy will span over a period of 8 weeks. **Frequency**: Sessions will be held daily for 8 weeks, with supervision provided by both a therapist and a parent. The child will attend therapy at the NSDU OPD 3 days per week, while the remaining days will involve practice at home. **Session Duration**: Each day will include a minimum of 4 hours of therapy. On NSDU OPD days, 90 minutes will be conducted at the facility, with the rest of the time completed at home. **Intensity**: The therapy will progress from static to dynamic modules. Initially, movements will be slow and gradually transition to self-paced propulsion by the child. **Further Progression:** a. Positioning the child more forward so that most of the pelvis is not supported by the MSB. b. Introducing additional resistance by placing weights on the upper limbs.	Total Duration: The therapy program will span 8 weeks. **Frequency**: Throughout this period, the child will engage in daily conventional exercises. These will be conducted three times a week at the NSDU outpatient department (OPD), while the remaining days will involve home-based sessions supervised by parents. **Session Duration**: Each day will include 4 hours of therapeutic exercises. On OPD days, 90 minutes of therapy will be carried out at NSDU, and the remaining time will be completed at home. On non-OPD days, the full session will be conducted at home under parental supervision. **Intensity**: The intensity is defined by the total daily exercise duration - 4 hours per day over 8 weeks. The exercises are categorized into three main areas: muscle range of motion, joint mobility, and muscle strength. Progression will be determined by measurable improvements in joint and muscle range, enhanced muscle activity reflected through posture and sitting control, and increased hip abduction range.
Precaution & Termination	a. The MSB therapy will include intervals of adequate rest after every 10 m of propulsion. b. Advancement from Module I to Module II will depend on the child's ability to maintain elbow extension during the static phase. c. Therapy will be paused if the child reports excessive fatigue. d. Sessions will also be suspended if the child is unwell and will resume once the child is fit to participate in the exercises.	

NSDU, Neurosensory development unit; MSB, Modified scooter board

muscles, which may be influenced by increased agonist and antagonist co-contraction following MSBT (Ganguly et al., 2021). These effects have an inhibitory effect on the overactive muscle and facilitate effective contraction of the muscle. In addition, the effect may also have been due to a nonneural component, especially the reduced viscous damping and elastic stiffness in the muscles, which are strongly influenced by the pattern of positioning used in the MSBT group (Ganguly et al., 2021). Although these effects support the present feasibility study findings, it is imperative to consider the nonsignificant significant differences. However, the previous literatures mainly emphasized the use of surgical interventions such as Obturator neurectomy, Botulinum toxin A injection and rehabilitative methods such as HRS (horse riding simulation) in reducing the adductor muscle tone. Although the result of the study indicates the reduction in the tone of adductor muscles of hip, these studies emphasize on the immediate or short-term effects and many still need further studies to validate the results. In contrast current MSBT intervention relatively feasible to be practised (Skoutelis et al., 2024; Hemachithra et al., 2020; Feygin et al., 2024).

When compared to the existing scooter board devices, therapy approaches and the interventions, the current protocol is relatively affordable for the patients as the overall cost burden borne by the parent to procure the device was INR 5k (60 USD). The overall cost is substantially lower compared to all the existing modes of the therapy which will significantly reduce the financial burden on the parents of the children with CP.

The overall objective of the proposed MSBT intervention was to improve the involvement and engagement of both the parent and the child with CP. Intervention effectiveness increases exponentially when a child is actively involved in exercise; however, the involvement of a child in exercise often decreases due to anxiety toward the exercise (Graham et al., 2019). In contrast, the MSBT programme compels the child to cause movement by themselves and involves the parent as a facilitator, in turn abolishing the state of anxiety experienced towards the exercises (Graham et al., 2019; Ryan et al., 2017). In addition, parents were readily involved with the exercises, as the implementation of the MSBT was very feasible since it merely involved positioning and encouraging the child to propel forward (Graham et al., 2019; Ryan et al., 2017).

The current pilot trial successfully implemented the MSBT intervention in children with CP, particularly those classified within Gross Motor Function Classification System (GMFCS) levels III to V. Children at these functional levels exhibit substantial limitations in ambulation and functional transitions due to multiple factors, as previously discussed. The findings of this study support the feasibility of administering the MSBT intervention in this population and demonstrate promising outcomes in enhancing volitional muscle activity around the hip joint.

4.1. Limitation

Although there were no statistically significant differences, the MSBT protocol however yielded a promising effect which warrants for a larger clinical trial to adequately generate the good evidence for the proposed intervention. In addition, the study lacked in formal assessment of adherence to the therapy and had not evaluated the anxiety level of the child using an objective measure. The future study can evaluate the specific outcomes such as level of anxiety, quality of life of child and parent, socio economic burden of parents etc. following the MSBT use.

5. Conclusion

The results of the study were used to generate the appropriate sample size for the study, which will evaluate the effect of the MSBT program in children with CP and address the limitations identified during the conduct of the MSBT program and test the efficacy in the larger population.

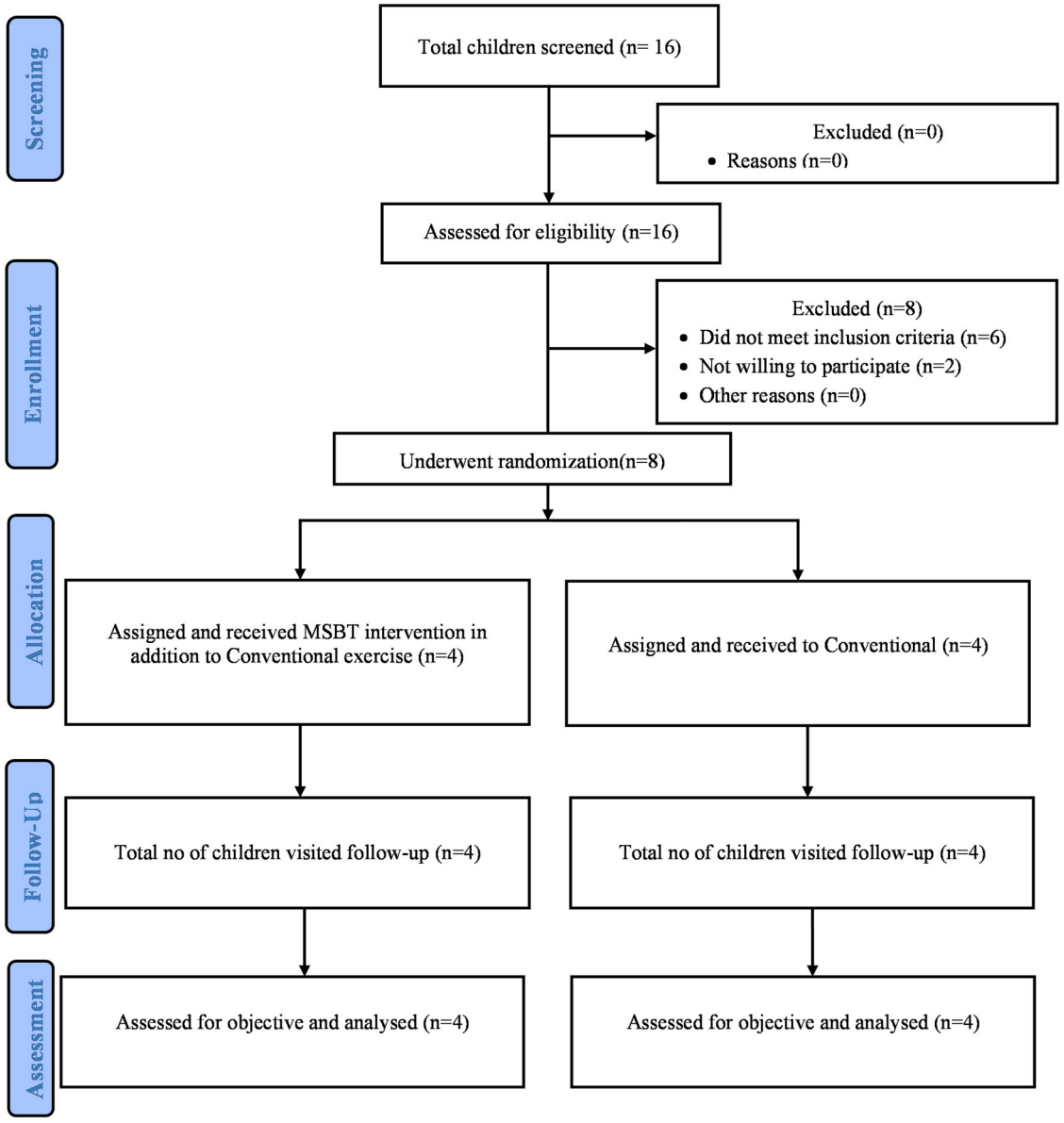

Fig. 3. Consort diagram.

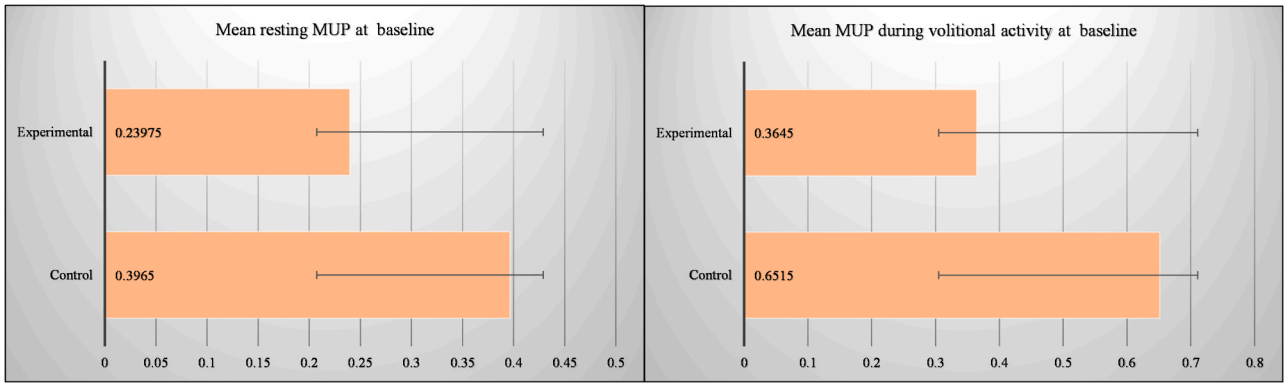

Fig. 4. Mean MUP at Baseline.

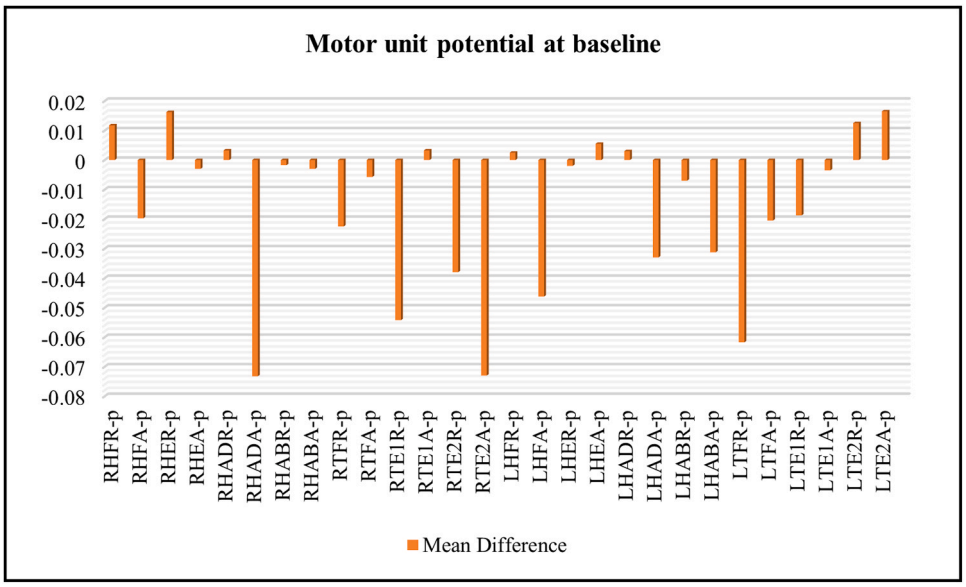

Fig. 5. MUP Mean difference at Baseline.

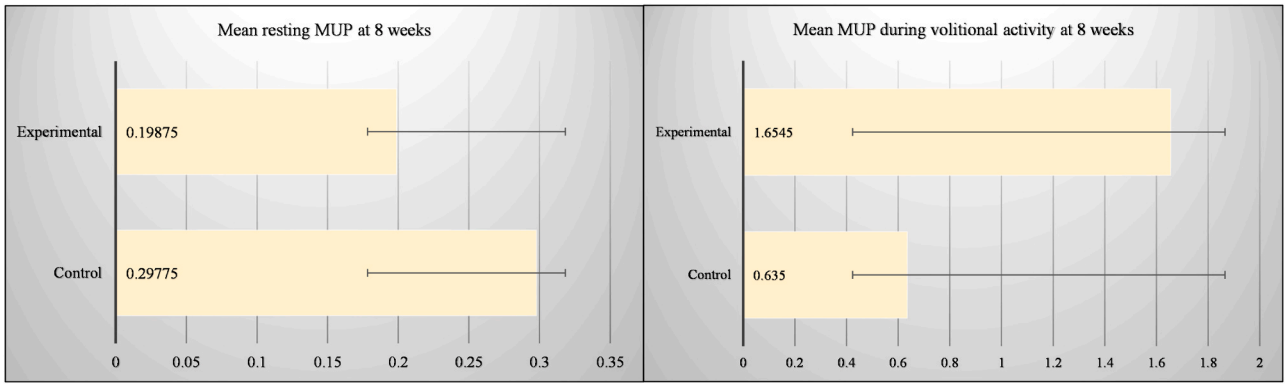

Fig. 6. Mean MUP at 8 weeks.

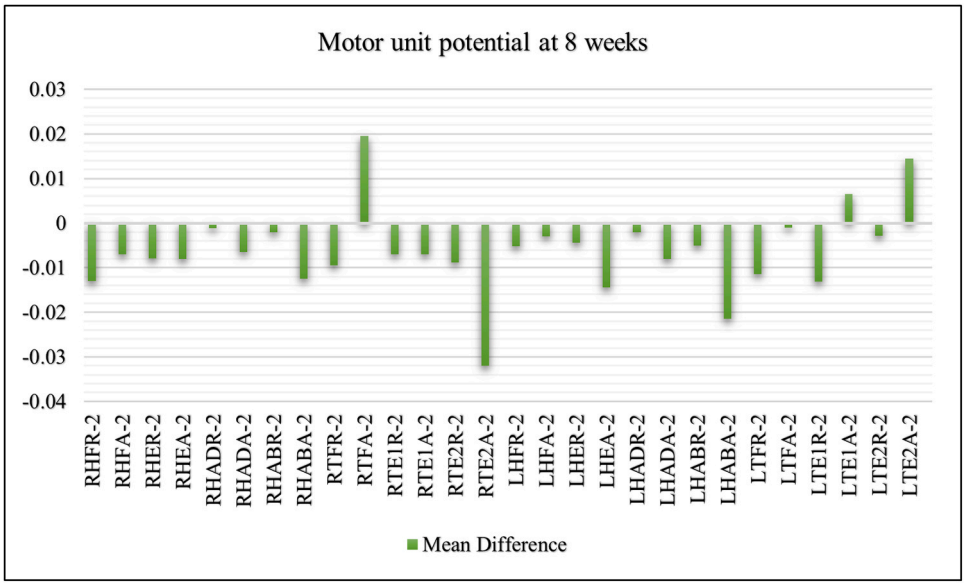

Fig. 7. MUP Mean difference at 8 weeks.

CRediT authorship contribution statement

Karnad Shreekanth D: Writing – review & editing, Writing – original draft, Visualization, Validation, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **K Vijaya Kumar:** Writing – review & editing, Supervision, Project administration. **Sharma Monika:** Writing – review & editing, Validation, Supervision, Project administration. **Rao Bhamini K:** Writing – review & editing, Validation, Supervision, Project administration. **Kamath Nutan:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Conceptualization. **Narayan Amitesh:** Writing – review & editing, Writing – original draft, Validation, Supervision, Resources, Project administration, Methodology, Conceptualization.

Ethics approval and consent to participate

Approval to conduct the pilot trial was obtained from the Institutional Ethics Committee of Kasturba Medical College, Mangalore, and was approved with reference no. IECKMCMLR-10/2022/414. The trial is registered under the Clinical Trial Registry of India with reference no. CTRI/2023/07/055707 on 26/07/2023. https://ctri.nic.in/Clinicaltrials/regtrial.php?modid= 1&compid= 19&EncHid= 53346.44240. Informed consent was obtained from the parents of the children prior to inclusion in the pilot trial.

Consent for publication

Informed consent was obtained from the parents of the included children prior to the beginning of the trial.

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Conflicts of Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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