Original Article

The Effect of Seat Surface Inclination on Postural Control and Upper Extremity Function in Children with Cerebral Palsy- A Crossover Study

[1]Riddhi Mistry, [2]Divya Mohan, [3]R.Vasanthan

[1]Student, [2-3]Professor, The Oxford College of Physiotherapy, Bengaluru, Karnataka

How to cite this article: Riddhi Mistry, Divya Mohan, R.Vasanthan. The Effect of Seat Surface Inclination on Postural Control and Upper Extremity Function in Children with Cerebral Palsy- A Crossover Study. Indian Journal of Physiotherapy and Occupational Therapy / Vol 20 No. 2, April - June 2026

Abstract

Background: Children with cerebral palsy spend prolonged periods in sitting, particularly in school settings. Adaptive seating, including seat surface inclination, may influence postural control and upper extremity function.

Methods: A cross-over study was conducted on 25 children with spastic cerebral palsy (8–13 years). Postural control and upper extremity function were assessed using the Sitting Assessment Scale, Seated Postural Control Measure, Functional Assessment Battery Tool, and ABILHAND-Kids Questionnaire under neutral, anterior, and posterior seat inclination conditions.

Results: Significant differences were observed across seating conditions in postural control, alignment, and selected upper extremity functional outcomes ($p < 0.05$).

Conclusion: A 10° seat inclination significantly influenced seated postural control and upper extremity function in children with spastic cerebral palsy.

Keywords: Cerebral palsy; postural control; upper extremity function; adaptive seating; seat inclination

Introduction

Cerebral palsy is a group of permanent disorders affecting the development of movement and posture, resulting in activity limitations and attributed to non-progressive disturbances in the developing fetal or infant brain.[1] In India, the pooled prevalence of cerebral palsy is reported as 2.95 per 1,000 children, while the global prevalence is approximately 2.11 per 1,000 live births.[2, 3] Cerebral palsy represents a heterogeneous group of motor disorders, most commonly classified by motor type and topographical distribution, with spastic cerebral palsy being the predominant form.[4-7]

Children with cerebral palsy frequently exhibit impairments in postural control due to muscle tightness, weakness, impaired selective motor control, and excessive co-contraction of antagonist muscles.[8-14] These impairments affect the ability to maintain and modify sitting posture and subsequently influence upper extremity function and participation in daily and school-related activities.[15,16]

Corresponding Author: Riddhi Mistry, Student, The Oxford College of Physiotherapy, Bengaluru, Karnataka

E-mail: mriddhi26@gmail.com

Submission: Jan 6, 2026 **Revision:** February 19, 2026 **Published date:** April 3 , 2026

Upper extremity dysfunction in cerebral palsy arises from both motor and sensory impairments, including reduced strength, limited range of motion, spasticity, poor coordination, and deficits in proprioception and tactile perception.[17-21] These deficits contribute to limitations in reaching, grasping, manipulation, and functional task performance, leading to restricted participation across home, school, and community environments.[22-24]

Pelvic positioning and trunk alignment are critical for achieving a functional sitting posture necessary for optimal upper extremity performance. Adequate postural control provides proximal stability, enabling improved distal upper limb mobility. Modifications in seating systems can alter pelvic and trunk orientation relative to gravity, thereby enhancing postural stability and functional arm use.[25-32]

Children with cerebral palsy spend a substantial amount of time in sitting, particularly in school settings, making adaptive seating strategies an important component of intervention. Anterior and posterior seat inclinations are commonly used to promote postural stability and functional performance.[33-34] Anterior seat inclination encourages anterior pelvic tilt and upright sitting posture, potentially enhancing upper limb function, whereas posterior seat inclination may increase stability by preventing forward sliding but can also increase postural effort.[35-38]

Previous studies have reported variable effects of seat inclination based on cerebral palsy subtype and angle of inclination. Seat inclinations around 10° have been associated with improved postural stability and reaching performance, while steeper inclinations appear to offer limited additional benefit.[39, 40] However, comparative evidence examining the effects of both anterior and posterior seat inclination on postural control and upper extremity function remains limited.

Therefore, the present study aimed to evaluate the effect of **anterior and posterior seat surface inclination** on seated postural control and upper extremity functional performance in children with spastic cerebral palsy.

Objective of the Study

To evaluate the effect of seat surface inclination on postural control and upper extremity function in children with cerebral palsy.

Materials and Methods

Ethical clearance was obtained from the Institutional Ethics Committee prior to the commencement of the study.

A total of 39 children with spastic cerebral palsy were screened for eligibility. Of these, 28 participants who met the selection criteria were recruited using a convenience sampling method from special schools and rehabilitation centers. Children aged 8–13 years diagnosed with spastic cerebral palsy (unilateral or bilateral), classified under the Manual Ability Classification System (MACS) levels I–III, able to understand and follow verbal commands, and having a passive hip flexion range of motion of 90° ± 10° (measured using a goniometer) were included.

Participants were excluded if they had severe visual impairment; upper extremity deformities involving the shoulder, elbow, or wrist; restricted shoulder range of motion (shoulder flexion or abduction <120°); fixed trunk deformities such as kyphosis or scoliosis or a positive Adam's forward bend test; or hip pain ≥5 on the Numerical Rating Scale (NRS-11).

A patient information sheet, informed consent form, informed assent form, and videography consent form were provided to the parent or class teacher of each participant, and written informed consent was obtained prior to participation.

This study employed a cross-over design, wherein each participant was exposed to both anterior and posterior seat inclinations using a custom-built foam wedge of 10°. A 15-minute familiarization period was provided for each seating condition, and outcome measures were recorded during each condition. A washout period of 30 minutes was allowed between seating conditions to minimize potential carry-over effects.

Assessments were conducted with participants seated on a standard chair with armrests, backrest, and footrest using the Sitting Assessment Scale, Seated Postural Control Measure, Functional Assessment Battery Tool, and ABILHAND-Kids Questionnaire.

Although 28 participants were initially recruited, complete data across all seating conditions were available for 25 participants only. Participants with incomplete assessment data or inability to complete both seating conditions as per the crossover protocol were excluded from the final analysis to ensure the integrity of within-subject comparisons.

Statistical Analysis

Statistical analysis was performed using SPSS version 28.0, with data from 25 participants analyzed according to the within-subject comparisons planned for the cross-over design. Sitting Assessment Scale scores were analyzed using Fisher's Exact Test; Seated Postural Control Measure, ABILHAND-Kids Questionnaire, and Functional Assessment Battery activities 1 and 7 were analyzed using repeated measures ANOVA; and Functional Assessment Battery activities 2–6 were analyzed using the Friedman test, with Bonferroni and Wilcoxon signed-rank tests applied for post-hoc analysis as appropriate. A p-value < 0.05 was considered statistically significant.

Results

Table 1: Demographic characteristics of subjects (n=25)

Characteristics	Frequency	%
Age- mean ± SD	11.72 ± 1.77	
Gender- Male	16	64
Gender- Female	9	36

All participants demonstrated good head control across seating conditions. Trunk control was predominantly good across positions, while foot, arm, and hand functions showed variation across normal, anterior, and posterior seating conditions (Table 2).

Table 2. Sitting Assessment Scale- Frequency and percentage of normal, anterior and posterior seat inclinations

		Normal		Anterior		Posterior	
		Frequency	%	Frequency	%	Frequency	%
Head control	Good	25	100	25	100	25	100
Trunk control	Fair	2	9.5	2	9.5	2	9.5
	Good	19	90.5	19	90.5	19	90.5
Foot control	Poor	0	0	0	0	1	4.8
	Fair	3	14.3	1	4.8	8	38.1
	Good	18	85.7	20	95.2	12	57.1
Arm function	Fair	12	57.1	9	42.9	11	52.4
	Good	9	42.9	12	57.1	10	47.6
Hand function	Fair	21	100	3	14.3	10	47.6
	Good	0	0	18	85.7	11	52.4

Significant associations between seating condition and trunk control and arm function were identified (Table 3)

Table 3. Comparison of trunk control, arm function, hand function, foot control between normal and anterior seats

		Anterior				Fisher's Exact Test	p value
		Fair		Good			
		N	%	N	%		
Trunk control (Normal)	Fair	2	100	0	0	0.003	**0.005***
	Good	0	0	19	100		
Arm function (Normal)	Fair	9	100	3	25	0.001	**0.001***
	Good	0	0	9	75		
Hand function (Normal)	Fair	3	100	18	100	--	--
Foot control (Normal)	Fair	1	100	2	10	0.143	0.143
	Good	0	0	18	90		

(* Significant)

Significant associations between seating condition and trunk control and arm function were identified (Table 4).

Table 4. Comparison of trunk control, arm function, hand function between normal and posterior seats

		Posterior				Fisher's Exact Test	p value
		Fair		Good			
		N	%	n	%		
Trunk control (Normal)	Fair	2	100	0	0	0.003	**0.005***
	Good	0	0	19	100		
Arm function (Normal)	Fair	10	90.9	2	20	0.002	**0.002***
	Good	1	9.1	8	80		
Hand function (Normal)	Fair	10	100	11	100	--	--

(* Significant)

A significant association between seating condition and foot control was identified (Table 5).

Table 5. Comparison of foot control betweenthe seats

		Posterior						Likelihood ratio	p value
		Poor		Fair		Good			
		N	%	n	%	N	%		
Foot control (Normal)	Fair	1	100	1	12.5	1	8.3	4.312	0.116
	Good	0	0	7	87.5	11	91.7		
Foot control (Anterior)	Fair	1	100	0	0	0	0	8.041	**0.018***
	Good	0	0	8	100	12	100		

(* Significant)

Significant associations between seating condition and trunk control and arm function were identified (Table 6).

Table 6. Comparison of trunk control, arm function, hand function between anterior and posterior seats

		Posterior				Fisher's Exact Test	p value
		Fair		Good			
		N	%	n	%		
Trunk control (Anterior)	Fair	2	100	0	0	0.003	**0.005***
	Good	0	0	19	100		
Arm function (Anterior)	Fair	9	81.8	0	0	0.0002	**< 0.001***
	Good	2	18.2	10	100		
Hand function (Anterior)	Fair	3	30	0	0	0.090	0.090
	Good	7	70	11	100		

(* Significant)

Significant differences in the alignment and functional sections were identified across seating conditions (Table 7).

Table 7. SPCM scale- Comparison of Level of Sitting Scale (LSS), alignment section, functional sectionaccording to the seats

		Mean	S.D.	"F'	p value
LSS	Normal	7.38	0.67	3.1	0.056
	Anterior	7.33	0.66		
	Posterior	7.10	0.62		
Alignment section	Normal	64.14	2.35	**38.057**	**< 0.001***
	Anterior	61.71	3.00		
	Posterior	57.95	3.63		
Functional section	Normal	42.29	1.15	**18.135**	< 0.001*
	Anterior	43.38	1.60		
	Posterior	41.95	1.16		

(* Significant)

Significant differences in the alignment and functional sections were identified across seating conditions (Table 8).

Table 8. Pairwise comparison of alignment section and functional section

Domain	Seat Comparison	Mean Difference	*p* value
Alignment	Normal vs Anterior	2.43	**0.014***
	Normal vs Posterior	6.19	**< 0.001***
	Anterior vs Posterior	3.76	< 0.001*
Functional	Normal vs Anterior	−1.10	**0.003***
	Normal vs Posterior	0.33	0.389
	Anterior vs Posterior	1.43	< 0.001*

(* Significant)

No significant differences were identified in overhead, forward, or sideways reaching across seating conditions (Table 9).

Table 9. Functional assessment battery- Comparison of overhead, forward, sideway according to the seats

		Mean	S.D.	"F'	p value
Overhead	Normal	55.33	6.78	0.235	0.792
	Anterior	56.07	7.33		
	Posterior	55.48	6.56		
Forward	Normal	53.14	6.58	2.536	0.107
	Anterior	56.00	7.24		
	Posterior	53.38	7.17		
Sideway	Normal	52.81	6.45	3.575	0.056
	Anterior	54.90	6.20		
	Posterior	53.24	6.14		

Significant differences were identified in Activities 4–6 across seating conditions (Table 10).

Table 10. Comparison of activity 2, 3, 4, 5 & 6according to the seats

Activity (sec)	Seat Comparison	Median	IQR	Friedman's ANOVA	p value
Activity 2	Normal	25	15.5 to 30	2.620	0.270
	Anterior	24	13.5 to 29		
	Posterior	22	13 to 29.5		
Activity 3	Normal	47	32.5 to 58	6.317	0.051
	Anterior	37	24 to 56		
	Posterior	45	28.5 to 55.5		
Activity 4	Normal	31	22.5 to 48.5	6.872	**0.032***
	Anterior	25	21 to 40		
	Posterior	32	19.5 to 37.5		
Activity 5	Normal	191.4	128.7 to 246	13.238	**0.001***
	Anterior	146.4	105 to 229.2		
	Posterior	180.6	93.6 to 231.6		
Activity 6	Normal	369	226.2 to 690	10.289	**0.006***
	Anterior	321	143.1 to 593.4		
	Posterior	327.6	137.4 to 627.6		

(* Significant)

Significant differences were identified in Activities 4–6 across seating conditions (Table 11).

Table 11. Pairwise comparison of activity 4, 5 and 6

Activity (sec)	Seat Comparison	Z value	*p* value
Activity 4	Normal vs Anterior	−2.529	**0.011***
	Normal vs Posterior	−2.265	**0.024***
	Anterior vs Posterior	−1.157	0.247
Activity 5	Normal vs Anterior	−3.181	**0.001***
	Normal vs Posterior	−1.930	0.054
	Anterior vs Posterior	−2.068	**0.039***
Activity 6	Normal vs Anterior	−3.319	**0.001***
	Normal vs Posterior	−2.798	**0.005***
	Anterior vs Posterior	−0.952	0.341

(* Significant)

Activity 7 differed significantly across seating conditions (Table 12).

Table 12. Comparison of activity 7according to the seats

		Mean	S.D.	"F'	p value
Activity 7 (Distance in Cm)	Normal	217.29	88.74	5.437	**0.019***
	Anterior	245.38	90.10		
	Posterior	235.62	93.44		

(* Significant)

Activity 7 differed significantly between neutral and anterior seating (Table 13).

Table 13. Pairwise comparison of activity 7

Activity 7 (Distance in Cm)		Mean Difference	p value
Normal	Anterior	-28.10	**0.031***
	Posterior	-18.33	0.255
Anterior	Posterior	9.76	0.169

(* Significant)

ABILHAND-Kids scores differed significantly across seating conditions (Table 14).

Table 14. Comparison of ABILHAND kids questionnaire according to the seats

		Mean	S.D.	"F'	p value
ABILHAND kids questionnaire	Normal	34.52	5.83	27.386	**< 0.001***
	Anterior	35.90	5.66		
	Posterior	33.67	6.19		

(* Significant)

Significant post-hoc differences were observed in ABILHAND-Kids scores (Table 15).

Table 15. Pairwise comparison of ABILHAND kid's questionnaire

ABILHAND kids questionnaire		Mean Difference	p value
Normal	Anterior	-1.38	**< 0.001***
	Posterior	0.86	**0.036***
Anterior	Posterior	2.24	**< 0.001***

(* Significant)

Results

Twenty-five children with spastic cerebral palsy participated in the study (mean age 11.72 ± 1.77 years; 64% male); baseline characteristics are presented in Table 1. Significant differences were observed in trunk, arm, hand, and foot control on the Sitting Assessment Scale and in the alignment and functional sections of the Seated Postural Control Measure across seating conditions (Tables 2–8). No significant differences were found in overhead, forward, or sideways reaching (Table 9); however, Functional Assessment Battery activities 4–7 and ABILHAND-Kids Questionnaire scores differed significantly across seating conditions (Tables 10–15).

Discussion

The present study examined the effect of anterior and posterior seat inclination on postural control and upper extremity function in children with spastic cerebral palsy. The findings demonstrated that seat inclination was associated with significant differences in seated postural control and selected upper extremity functional tasks.

Postural Control and Seat Inclination

The results indicated significant differences in postural control across seating conditions, as reflected by the Sitting Assessment Scale and Seated Postural Control Measure. Improvements in trunk control and arm function were observed with seat inclination, particularly with anterior seating. Anterior seat inclination promotes an upright sitting posture by facilitating anterior pelvic tilt and reducing slouched sitting, which may enhance proximal stability. In contrast, foot control was reduced in posterior seat inclination, possibly due to decreased weight-bearing through the feet.

The Seated Postural Control Measure demonstrated significant differences in both alignment and functional sections across seating conditions. Functional performance appeared more favourable in anterior and neutral seating, while alignment scores were relatively better in neutral seating. These findings suggest that seat inclination influences pelvic and trunk alignment, which in turn affects postural stability during sitting.

Previous studies have reported similar findings. Cherng et al. reported improved postural stability with anterior seat inclination, attributed to increased weight-bearing through the feet. Hadders-Algra et al. observed improved postural control and reaching performance with forward seat inclination in children with unilateral spastic cerebral palsy, while horizontal seating was more beneficial for children with bilateral involvement. The present study similarly found anterior seat inclination to be associated with better postural stability, particularly in children with milder involvement.

Upper Extremity Function and Seat Inclination

Significant differences were observed in selected upper extremity functional tasks across seating conditions. Functional Assessment Battery activities involving fine motor skills, bimanual coordination, and visual-motor integration demonstrated improved performance with anterior and neutral seating compared to posterior seating. Activity 7 (throwing a ball) showed greater throwing distance in anterior

seating, which may be attributed to improved trunk alignment, increased sitting height, and better lower limb support.

These findings are consistent with previous reports indicating faster task performance and improved reaching efficiency with anterior seat inclination compared to posterior inclination. The present study also demonstrated that time-based functional tasks were performed more efficiently in anterior and neutral seating conditions.

Several factors may have influenced task performance, including prior experience with functional activities, attention, motivation, fatigue, and fear associated with task execution. Additionally, many participants were classified as GMFCS levels I–II and had limited experience with wheelchair use, which may have affected scores related to wheelchair-based functional components.

Overall, anterior seat inclination may be beneficial for postural control and upper extremity function in children with spastic cerebral palsy.

Limitations

The lengthy assessment protocol may have influenced performance due to fatigue and variable engagement. In addition, the predominance of participants classified as GMFCS levels I–II, with limited wheelchair experience, may have affected functional section scores of the Seated Postural Control Measure.

Future Recommendations

Seat inclination may be considered as an adjunct to improve functional activity performance in children with spastic cerebral palsy.

Clinical Implications

Given that children with cerebral palsy spend considerable time in sitting, particularly in school settings, a custom-built foam wedge with a 10° anterior or posterior seat inclination may be considered during functional activities to facilitate postural control and upper extremity function.

Conclusion

Anterior and posterior seat inclinations were associated with statistically significant differences in postural control and upper extremity function, as reflected by improvements in SAS, SPCM, selected Functional Assessment Battery activities (4–7), and ABILHAND-Kids Questionnaire scores in children with spastic cerebral palsy.

Ethical Clearance: Ethical clearance for this study was obtained from the Institutional Ethics Committee of The Oxford College of Physiotherapy. Approval was granted as per reference number TOCPTRBERS001/2022 dated 06 January 2022.

Source of Funding: Self

Conflict of Interest: NIL

References

1. Bax M, Goldstein M, Rosenbaum P, Leviton A, Paneth N, Dan B, Jacobsson B, Damiano D. Proposed definition and classification of cerebral palsy, April 2005. *Developmental Medicine and Child Neurology.* 2005 Aug;47(8):571-6.
2. Chauhan A, Singh M, Jaiswal N, Agarwal A, Sahu JK, Singh M. Prevalence of cerebral palsy in Indian children: a systematic review and meta-analysis. *The Indian Journal of Pediatrics.* 2019 Dec;86(12):1124-30.
3. Oskoui M, Coutinho F, Dykeman J, Jetté N, Pringsheim T. An update on the prevalence of cerebral palsy: a systematic review and meta-analysis. *Developmental Medicine & Child Neurology.* 2013 Jun;55(6):509-19.
4. Paulson A, Vargus-Adams J. Overview of four functional classification systems commonly used in cerebral palsy. *Children.* 2017 Apr;4(4):30.
5. Graham HK. Classifying cerebral palsy. *Journal of Pediatric Orthopaedics.* 2005 Jan 1;25(1):127-8.
6. Banerjee TK, Hazra A, Biswas A, Ray J, Roy T, Raut DK, Chaudhuri A, Das SK. Neurological disorders in children and adolescents. *The Indian Journal of Pediatrics.* 2009 Feb;76(2):139-46.
7. Singhi PD, Ray M, Suri G. Clinical spectrum of cerebral palsy in North India—an analysis of 1000 cases. *Journal of Tropical Pediatrics.* 2002 Jun 1;48(3):162-6.
8. Chung J, Evans J, Lee C, Lee J, Rabbani Y, Roxborough L, Harris SR. Effectiveness of adaptive seating on sitting posture and postural control in children with

cerebral palsy. *Pediatric Physical Therapy.* 2008 Dec 1;20(4):303-17.

9. Huang IC, Sugden D, Beveridge S. Assistive devices and cerebral palsy: factors influencing the use of assistive devices at home by children with cerebral palsy. *Child: care, health and Development.* 2009 Jan;35(1):130-9.
10. Brogren E, Forssberg H, Hadders-Algra M. Influence of two different sitting positions on postural adjustments in children with spastic diplegia. *Developmental Medicine and Child Neurology.* 2001 Aug;43(8):534-46.
11. Van Der Heide JC, Begeer C, Fock JM, Otten B, Stremmelaar E, Van Eykern LA, Hadders-Algra M. Postural control during reaching in preterm children with cerebral palsy. *Developmental Medicine and Child Neurology.* 2004 Apr;46(4):253-66.
12. Donker SF, Ledebt A, Roerdink M, Savelsbergh GJ, Beek PJ. Children with cerebral palsy exhibit greater and more regular postural sway than typically developing children. *Experimental Brain Research.* 2008 Jan 1;184(3):363-70.
13. Carlberg EB, Hadders-Algra M. Postural dysfunction in children with cerebral palsy: some implications for therapeutic guidance. *Neural Plasticity.* 2005 Jan 1;12(2-3):221-8.
14. Brogren E, Hadders-Algraa M, Forssberg H. Postural control in sitting children with cerebral palsy. *Neuroscience &Biobehavioral Reviews*. 1998 Mar 4;22(4):591-6.
15. Schiariti V, Klassen AF, Cieza A, Sauve K, O'Donnell M, Armstrong R, Mâsse LC. Comparing contents of outcome measures in cerebral palsy using the International Classification of Functioning (ICF-CY): a systematic review. *European Journal of Paediatric Neurology.* 2014 Jan 1;18(1):1-2.
16. Çankaya Ö, Seyhan K. ICF-CY-Based Physiotherapy Management in Children with Cerebral Palsy. *Cerebral Palsy: Current Steps.* 2016 Sep 21:79.
17. Arner M, Eliasson AC, Nicklasson S, Sommerstein K, Hägglund G. Hand function in cerebral palsy. Report of 367 children in a population-based longitudinal health care program. *The Journal of Hand Surgery.* 2008 Oct 1;33(8):1337-47.
18. Arnould C, Penta M, Thonnard JL. Hand impairments and their relationship with manual ability in children with cerebral palsy. *Journal of Rehabilitation Medicine.* 2008 Nov 5;39(9):708-14.
19. Fedrizzi E, Pagliano E, Andreucci E, Oleari G. Hand function in children with hemiplegic cerebral palsy: prospective follow-up and functional outcome in adolescence. *Developmental Medicine and Child Neurology.* 2003 Feb;45(2):85-91.
20. Mackey AH, Walt SE, Stott NS. Deficits in upper-limb task performance in children with hemiplegic cerebral palsy as defined by 3-dimensional kinematics. *Archives of physical medicine and Rehabilitation*. 2006 Feb 1;87(2):207-15.
21. Uvebrant P. Hemiplegic cerebral palsy aetiology and outcome. *Acta Paediatrica.* 1988 May;77:1-00.
22. Lemmens RJ, Janssen-Potten YJ, Timmermans AA, Defesche A, Smeets RJ, Seelen HA. Arm hand skilled performance in cerebral palsy: activity preferences and their movement components. *BMC Neurology.* 2014 Dec;14(1):1-0.
23. Steenbergen B, Gordon AM. Activity limitation in hemiplegic cerebral palsy: evidence for disorders in motor planning. *Developmental Medicine and Child Neurology.* 2006 Sep;48(9):780-3.
24. Arnould C, Bleyenheuft Y, Thonnard JL. Hand functioning in children with cerebral palsy. *Frontiers in Neurology*. 2014 Apr 9;5:48.
25. Costigan FA, Light J. Effect of seated position on upper-extremity access to augmentative communication for children with cerebral palsy: Preliminary investigation. *American Journal of Occupational Therapy.* 2010 Jul 1;64(4):596-604.
26. Rodby-Bousquet E, Hägglund G. Sitting and standing performance in a total population of children with cerebral palsy: a cross-sectional study. *BMC Musculoskeletal Discord.*2010 Jun 23;11:131. doi: 10.1186/1471-2474-11-131. PMID: 20573201; PMCID: PMC2908562.
27. Zulkapli NZ, Saat NZ, Kamaralzaman S. Postural control influence on upper extremity function among children with cerebral palsy: a literature review. *Jurnal Sains Kesihatan Malaysia (Malaysian Journal of Health Sciences)*. 2016 Jun 30;14(2).
28. Field DA, Roxborough LA. Responsiveness of the Seated Postural Control Measure and the Level of Sitting Scale in children with neuromotor disorders. *Disability and Rehabilitation: Assistive Technology.* 2011 Nov 1;6(6):473-82.
29. Mcnamara L, Casey J. Seat inclinations affect the function of children with cerebral palsy: a review of the effect of different seat inclines. *Disability and Rehabilitation: Assistive Technology.* 2007 Jan 1;2(6): 309-18.
30. Angsupaisal M, Maathuis CG, Hadders-Algra M. Adaptive seating systems in children with severe cerebral palsy across International Classification

of Functioning, Disability and Health for Children and Youth version domains: a systematic review. *Developmental Medicine & Child Neurology.* 2015 Oct;57(10):919-30.

31. Stavness C. The effect of positioning for children with cerebral palsy on upper-extremity function: a review of the evidence. *Physical & Occupational Therapy in Pediatrics.* 2006 Jan 1;26(3):39-53.
32. Green EM, Nelham RL. Development of sitting ability, assessment of children with a motor handicap and prescription of appropriate seating systems. *Prosthetics and orthotics International.* 1991 Dec;15(3):203-16.
33. Nwaobi OM. Seating orientations and upper extremity function in children with cerebral palsy. *Physical Therapy.* 1987 Aug 1;67(8):1209-12.
34. Michael SM, Porter D, Pountney TE. Tilted seat position for non-ambulant individuals with neurological and neuromuscular impairment: a systematic review. *Clinical rehabilitation.* 2007 Dec;21(12):1063-74.
35. Myhr U, von Wendt L. Improvement of functional sitting position for children with cerebral palsy. *Developmental Medicine & Child Neurology.* 1991 Mar;33(3):246-56.
36. Myhr U, von Wendt L. Influence of different sitting positions and abduction orthoses on leg muscle activity in children with cerebral palsy. *Developmental Medicine & Child Neurology.* 1993 Oct;35(10):870-80.
37. Sochaniwskyj A, Koheil R, Bablich K, Milner M, Lotto W. Dynamic monitoring of sitting posture for children with spastic cerebral palsy. *Clinical Biomechanics.* 1991 Aug 1;6(3):161-7.
38. Reid DT. The effects of the saddle seat on seated postural control and upper-extremity movement in children with cerebral palsy. *Developmental Medicine & Child Neurology.* 1996 Sep;38(9):805-15.
39. Cherng RJ, Lin HC, Ju YH, Ho CS. Effect of seat surface inclination on postural stability and forward reaching efficiency in children with spastic cerebral palsy. *Research in Developmental Disabilities.* 2009 Nov 1;30(6):1420-7.
40. Hadders-Algra M, Van der Heide JC, Fock JM, Stremmelaar E, Van Eykern LA, Otten B. Effect of seat surface inclination on postural control during reaching in preterm children with cerebral palsy. *Physical Therapy.* 2007 Jul 1;87(7):861-71.
41. McClenaghan BA, Thombs L, Milner M. Effects of seat-surface inclination on postural stability and function of the upper extremities of children with cerebral palsy. *Developmental Medicine & Child Neurology*. 1992 Jan;34(1):40-8.
42. Angsupaisal M. Adaptive seating and adaptive riding in children with cerebral palsy: In children with cerebral palsy.*Research in Developmental Disabilities* 2017 Sep; 71:42–52
43. Matusiak-Wieczorek E, Dziankowska-Zaborszczyk E, Synder M, Borowski A. The influence of hippotherapy on the body posture in a sitting position among children with cerebral palsy. *International journal of environmental research and public health.* 2020 Jan;17(18):6846.
44. Myhr, U. Manual for the Sitting Assessment Scale; Boden University College of Health Sciences: Boden, Sweden, 1993.
45. Myhr U, von Wendt L. Reducing spasticity and enhancing postural control for the creation of a functional sitting position in children with cerebral palsy: A pilot study. *Physiotherapy Theory and Practice.* 1990 Jan 1;6(2):65-76.
46. Arnould C, Penta M, Renders A, Thonnard JL. ABILHAND-Kids: a measure of manual ability in children with cerebral palsy. *Neurology.* 2004 Sep 28;63(6):1045-52.
47. Chow, Shao and Wang, Sample Size Calculations in Clinical Research, https://www2.ccrb.cuhk.edu.hk/stat/mean/tsmc_equivalence.htm*Taylor & Francis*, NY. (2003) Pages 66-67
48. Sahinoğlu D, Coskun G, Bek N. Effects of different seating equipment on postural control and upper extremity function in children with cerebral palsy. *Prosthetics and orthotics International*. 2017 Feb;41(1):85-94.
49. Fife SE, Roxborough LA, Armstrong RW, Harris SR, Gregson JL, Field D. Development of a clinical measure of postural control for assessment of adaptive seating in children with neuromotor disabilities. *Physical Therapy*. 1991 Dec 1;71(12):981-93.