



Design Guidelines for Adaptive Seating for Children with Cerebral Palsy: A Case Study in Kuala Lumpur

Fatimahwati Hamzah^{1*}, Sazlina Kamaralzaman², Saiful Hasley Ramly³, Intan Suria Hamzah⁴, Mohd Fakhrul Azri Abdullah⁵, Rosalam Che Me³

¹Kolej Komuniti Kuala Langat, Jalan Sultan Suleiman Shah, Kampung Kathong, 42700 Banting, Selangor, Malaysia

²Faculty of Health Sciences, Universiti Kebangsaan Malaysia, Jalan Raja Muda Abdul Aziz 50300 Kuala Lumpur, Malaysia

³Faculty of Design and Architecture, Universiti Putra Malaysia, Persiaran Universiti 2, 43400 Seri Kembangan, Selangor, Malaysia

⁴Faculty of Human Sciences, Universiti Pendidikan Idris Shah, 35900 Tanjong Malim, Perak, Malaysia

⁵HICOM HBPO Sdn Bhd, 35900 Proton City, Tanjung Malim, Perak, Malaysia

*Corresponding author: fatimahwati@kkkla.edu.my

Please provide an **official organisation email** of the corresponding author

Full Paper

Article history

Received

14 March 2025

Received in revised form

11 June 2025

Accepted

4 July 2025

Published online

1 November 2025



Abstract

Children with cerebral palsy (CP) often experience challenges in maintaining postural stability and mobility due to muscle tone irregularities and motor impairments. Adaptive seating solutions provide proper postural support, enhance functional movement, and ensure comfort. However, many existing seating solutions lack the flexibility and ergonomic considerations necessary for accommodating the diverse needs of children with CP. This study aims to develop comprehensive design guidelines for adaptive seating by analyzing real-world challenges children, caregivers, and rehabilitation specialists face. A case study was conducted at two rehabilitation clinics in Kuala Lumpur, involving interviews with two physiotherapists and one occupational therapist, alongside direct observations of children using adaptive seating. Additionally, caregiver feedback was gathered to assess usability and daily practical challenges. The findings emphasize key design aspects such as adjustability, postural support, pressure management, accessibility, safety, growth adaptability, and material selection. A significant issue identified was the lack of modularity in existing seating, leading to frequent replacements as children grow. Therapists highlighted the importance of using durable, hypoallergenic, and easy-to-clean materials to ensure hygiene and longevity. Furthermore, user-friendly features such as swing-away footrests and secure harnessing systems were recommended to enhance safety and ease of use. By incorporating insights from rehabilitation specialists and caregivers, this research establishes practical design guidelines for adaptive seating tailored to the specific needs of children with CP. Future innovations should explore smart assistive technologies and modular designs to improve adaptability and long-term usability, thereby enhancing the quality of life for children and reducing caregiver burden.

Keywords: - Cerebral palsy, adaptive seating, postural stability, ergonomic design, rehabilitation

Copyright © This is an open access article distributed under the terms of the Creative Commons Attribution License



1. Introduction

Children with cerebral palsy (CP) frequently struggle with maintaining postural stability and functional mobility due to abnormalities in muscle tone and motor deficits.

Adaptive seating systems are essential for improving posture, comfort, and engagement in daily activities. However, many commercial seating solutions lack the ergonomic flexibility and user-centered features required to meet the diverse and evolving needs of children with CP. This has prompted a growing interest in developing

context-sensitive, adaptable designs that are both therapeutic and practical.

Recent studies emphasize the therapeutic value of postural control as well as the various difficulties experienced by kids with cerebral palsy. According to Garrido-Ardila et al. (2021) & Zukić et al. (2021), supported sitting can improve rehabilitation outcomes and highlight the need of early interventions and structured mobility programs. This is further supported by Liang et al. (2021) & Acharya et al. (2023), who show that adaptable sitting enhances postural alignment and exercise performance. In a similar vein, Ashraf & Nisar (2019) emphasize how proper child positioning can improve the development of fine motor skills, illustrating the connection between upper limb function and chair support.

Beyond only providing physical support, seating design is important. According to Nurhastuti et al. (2019) & Mohanty et al. (2021), user-friendly and customizable designs can enable families to take a more active role in their child's care. They also highlight the importance of parental participation and the necessity of explicit caregiver education. This viewpoint is consistent with Tambunan et al. (2023), who contend that effective communication and comprehension between caregivers and children are critical to the success of rehabilitation, and that sitting design can either facilitate or impede this process.

Poorly constructed seating can hinder communication (Kavlak & Tekin, 2019), delay therapy (Kanyembo et al., 2021) and worsen secondary problems including food difficulties (Sakhaei et al., 2019) or sleep disorders (Gamayani et al., 2022; Munyumu et al., 2018). Additionally, Elsayed et al. (2021) & Korkmaz et al. (2022) demonstrate how well-designed seating solutions can enhance visual-motor integration and lessen spinal misalignment, both of which increase treatment effects.

Particularly in educational settings, Espinoza et al. (2023) & Tofani et al. (2021) favor inclusive, uniform, and psychologically supportive seating arrangements. According to Zhao et al. (2024), adaptable seating systems with sensor-based feedback and modular components could improve the integration of smart technologies and tele-rehabilitation.

When taken as a whole, the literature consistently shows that ergonomic, customized, inclusive, and clinically and caregiver-informed adapted seating is needed. Even with increased knowledge, many goods are still rigid, out-of-date, or prohibitively expensive, particularly in settings with limited resources (Abdallah et al., 2021).

Thus, the purpose of this study is to create useful, therapist-informed design guidelines for adapted seating that are specific to children with cerebral palsy in Malaysia. Based on real-world sitting usage observations, rehabilitation specialist interviews, and caregiver input, the study aims to pinpoint the design elements that are most important for long-term flexibility, safety, postural support, and usability.

2. Methodology

A qualitative research approach was employed to analyze the challenges and requirements of adaptive seating for children with CP. The study was conducted at two rehabilitation clinics in Kuala Lumpur, where data was collected through structured interviews, and direct observations. Three rehabilitation specialists participated in the study: two physiotherapists and one occupational therapist. Semi-structured interviews were conducted to gain in-depth insights into the postural challenges, usability concerns, and limitations of existing adaptive seating solutions. The therapists provided detailed feedback on key design elements that could improve functionality and comfort for children with CP. Direct observations were conducted during therapy sessions to evaluate how children interacted with their adaptive seating, focusing on posture alignment, seat adjustability, pressure distribution, and ease of movement. Therapists provided real-time assessments, noting that many children struggled with maintaining proper posture due to insufficient lateral and pelvic support. They also highlighted the need for better pressure redistribution features, as prolonged sitting often led to discomfort. Additionally, therapists emphasized the importance of customizable adjustments to accommodate growth and varying postural needs, ensuring optimal functionality and long-term usability of the seating solutions. Interview transcripts and observation notes were analyzed using thematic analysis. Key themes were identified through iterative coding and reviewed collaboratively among the researchers to ensure reliability. Fig. 1 shows the adaptive seating sample as a subject.



Fig. 1: Adaptive seating (Source: Physiotherapy Unit in KL)

3. Result and Discussion

The findings from the case study using thematic analysis highlight several critical design considerations for adaptive seating. Table 1 presents key design elements, issues identified from the rehabilitation clinics, and proposed solutions based on therapist and caregiver feedback.

The findings in Table 1 indicate that the proposed adaptive seat design has various deliberate elements specifically designed for children with cerebral palsy, prioritizing comfort, safety, and adjustability. Fig. 2 shows the proposed adaptive seat design.

The grounded results of therapist interviews and direct observation sessions led to the creation of a suggested

adapted seating design, which identified notable shortcomings in the available sitting solutions for kids with cerebral palsy (CP). These findings are used in the final concept, which is depicted in Fig. 2, to provide an ergonomic and modular solution that meets both short-term postural requirements and long-term flexibility. A key component of this design is displayed in Table 2.

Table 1: Key design considerations for adaptive seating

Design Element	Identified Issues from Case Study	Proposed Solutions
Adjustability & Customization	Existing seating lacked flexibility, leading to poor posture and discomfort. Many children outgrew their seats quickly.	Incorporate adjustable seat depth, width, backrest angle, and footrests to accommodate growth and varying postural needs.
Postural Support & Stability	Children had difficulty maintaining an upright position due to inadequate headrests, lateral supports, and pelvic stabilizers.	Use customizable headrests, lateral supports, and pelvic positioning straps to ensure proper posture and prevent muscle fatigue.
Pressure Redistribution & Comfort	Prolonged sitting led to discomfort and pressure sores, especially for non-mobile children. Existing cushions lacked pressure relief.	Use memory foam or gel-based cushions to distribute weight evenly, reducing pressure points and improving comfort.
Accessibility & Ease of Use	Caregivers found it difficult to transfer children in and out of seats, especially when lifting was required.	Integrate removable armrests, swing-away footrests, and height-adjustable features for easier transfers.
Safety Considerations	Some seating systems lacked adequate harnesses, leading to risk of falls and unintended movements.	Implement secure harnesses, anti-tip mechanisms, and non-slip materials to enhance safety.
Growth Adaptability	Many seating solutions needed frequent replacements as children grew, increasing costs and burden on families.	Develop modular designs that allow for replaceable and expandable components to accommodate growth.
Material Selection & Durability	Existing seating materials were difficult to clean and deteriorated quickly, leading to hygiene concerns.	Use hypoallergenic, moisture-resistant, and easy-to-clean materials to improve longevity and hygiene.



Fig. 2: Proposed adaptive seat design

Table 2: Features of the proposed adaptive seat design

1. Modular Components	The chair is constructed in a way that allows parts (like the backrest, seat, footrest, or arm supports) to be removed, replaced, or resized. Supports long-term use as children grow or their needs change.
2. V-shaped backrest with an adjustable angled position	Enables the seat to extend or shorten to fit different leg lengths. Ensures proper posture, preventing slouching or overreaching. V-shaped system secures the child at the shoulders, chest, and hips. Adjustable to accommodate different body sizes and ensure stability. Designed for full spinal and neck support, especially for children with poor trunk control.
3. Removable Arm Cushion	Provide lateral support to stabilize the trunk. Can be removed for easier side transfers or reconfiguration.
4. Seat stopper or Abduction Block with foam cushion	The seat includes high-density cushion foam to distribute pressure evenly. A central abduction block prevents leg crossing and promotes correct hip alignment.
5. Swing-Away Footrest	Moves aside to facilitate easy entry and exit from the seat. Height-adjustable to support the feet and promote circulation.
6. Durable & Hygienic Materials	Surfaces are easy to clean, moisture-resistant, and hypoallergenic. Ideal for regular use in therapy centers and homes.

Future advancements should focus on smart seating systems with pressure sensors and real-time feedback applications. Additional study is required on materials that have the potential to enhance comfort and hygiene, such as medical-grade viscoelastic foam and antimicrobial textiles.

4. Conclusion

Adaptive seating plays a crucial role in enhancing the quality of life for children with CP by providing necessary postural support and promoting functional independence.

This work offers a useful but theoretically grounded adaptable seating design option for kids with cerebral palsy. We discovered fundamental ergonomic and functional flaws in the current sitting systems by using first-hand observation and qualitative information obtained from rehabilitation specialists. Important elements that not only meet physical postural needs but also conform to neurodevelopmental and biomechanical theories are incorporated into the suggested design, including modular components, foam cushioning with abduction support, a high-back upholstered v-shaped backrest, and swing-away footrests. The seating system is based on the the International Classification of Functioning, Disability and Health (ICF) framework (World Health Organization, 2001) and promotes caregiver usability and functional engagement. Its modular design reflects a long-term, sustainable approach to assistive technology. In the end, our design adds to the expanding corpus of research supporting context-specific, inclusive, and adaptive interventions that support the safety, well-being, and autonomy of children with cerebral palsy and their caregivers.

Acknowledgement: The authors would like to extend their heartfelt gratitude to Kolej Komuniti Kuala Langat for their invaluable support in facilitating this research. Sincerely appreciation to the physiotherapists, occupational therapists, caregivers, and children involved in the study, whose insights and experiences were crucial in shaping the findings. Furthermore, thank you to all collaborators whose expertise and dedication made this study possible. Their collective efforts have played a vital role in advancing the understanding and development of adaptive seating solutions for children with cerebral palsy.

Author Contributions: The research study was carried out successfully with contributions from all authors.

Conflicts of Interest: The authors declare no conflict of interest.

References

- Abdallah, M. A., Abdelaziem, F., & Soliman, M. (2022). Prevalence of the need for adaptive seating systems among children with cerebral palsy in Egypt. *Prosthetics and orthotics international*, 46(1), 7-11. <https://doi.org/10.1097/pxr.0000000000000065>.
- Acharya, B. D., Karki, A., Prasertsukdee, S., Reed, D., Rawal, L., Baniya, P. L., & Boyd, R. N. (2023). Effect of adaptive seating systems on postural control and activity performance: a systematic review. *Pediatric Physical Therapy*, 35(4), 397-410. <https://doi.org/10.1097/pep.0000000000001042>.
- Ashraf, S., & Nisar, F. (2019). Development of Fine Motor Skills to Enhance the Functional Abilities of Children With Cerebral Palsy. *Responsible Education, Learning and Teaching in Emerging Economies*, 1(1), 31-36. <https://doi.org/10.26710/relate.v1i1.1120>.
- Elsayed, A. M., Salem, E. E., Eldin, S. M. N., & Abbass, M. E. (2021). Effect of using adaptive seating equipment on grasping and visual motor integration in children with hemiparetic cerebral palsy: a randomized controlled trial. *Bulletin of Faculty of Physical Therapy*, 26(1), 25. <https://doi.org/10.1186/s43161-021-00046-8>.
- Espinoza, V. M. T., Shaimardanova, M., Shakhmalova, I., & Garina, E. (1863). Transformation of the learning environment for children with special needs. *Int J Eval & Res Educ ISSN*, 2252, 8822. <https://doi.org/10.11591/ijere.v12i4.24539>.
- Gamayani, U., Aryani, M., Lailiyya, N., & Pusparini, I. (2022). Sleep disorder prevalence and influencing factors in children with cerebral palsy. *Global Medical & Health Communication (GMHC)*, 10(1), 28-34. <https://doi.org/10.29313/gmhcv10i1.8789>.
- Garrido-Ardila, E. M., Caro-Puertolas, B., Jiménez-Palomares, M., Montanero-Fernández, J., Rodríguez-Domínguez, T., & Rodríguez-Mansilla, J. (2021). Orthopaedic disorders in cerebral palsy in international cooperation projects: A descriptive cross-sectional study. *International Journal of Environmental Research and Public Health*, 18(15), 7872. <https://doi.org/10.3390/ijerph18157872>.
- Kanyembo, C., Chiluba, B. C., & Moyo, G. (2021). Factors Contributing to Late Physiotherapy Intervention of Children with Cerebral Palsy at The University Teaching Hospital, Lusaka in Zambia. *Indonesian Journal of Disability Studies*, 8(1), 1-21. <https://doi.org/10.21776/ub.ijds.2021.008.01.01>.
- Kavlak, E., & Tekin, F. (2019). Examining various factors affecting communication skills in children with cerebral palsy. *NeuroRehabilitation*, 44(2), 161-173. <https://doi.org/10.3233/nre-182580>.
- Korkmaz, M. D., Korkmaz, M., Capan, N., Sanli, G., Tatar, Y., & Aydin, A. R. (2022). Seating system for scoliosis in nonambulatory children with cerebral palsy: a randomized controlled trial. *Revista da Associação Médica Brasileira*, 68, 616-621. <https://doi.org/10.1590/1806-9282.20211260>.

- Liang, X., Zhujiang, T. A. N., Guojun, Y. U. N., Jianguo, C. A. O., Jinggang, W. A. N. G., Qing, L. I. U., & Turong, C. H. E. N. (2020). Effectiveness of exercise interventions for children with cerebral palsy: A systematic review and meta-analysis of randomized controlled trials. *Journal of rehabilitation medicine*, 53(4), 2733.
<https://doi.org/10.2340/16501977-2772>.
- Mohanty, M., Beaulieu, F., Sampath, S., Tambunan, D., Kataria, S., & Rosman, N. P. (2021). "Your Child Has Cerebral Palsy": Parental Understanding and Misconceptions. *Journal of Child Neurology*, 36(8), 648-654. <https://doi.org/10.1177/0883073821991300>.
- Munyumu, K., Idro, R., Abbo, C., Kaddumukasa, M., Katabira, E., Mupere, E., & Kakooza-Mwesige, A. (2018). Prevalence and factors associated with sleep disorders among children with cerebral palsy in Uganda; a cross-sectional study. *BMC pediatrics*, 18(1), 26.
<https://doi.org/10.1186/s12887-018-0996-z>.
- Nurhastuti, N., Iswari, M., Kasiyati, K., Zulmiyetri, Z., & Irdamurni, I. (2019, December). Analysis of the Needs of Parents Who Have Cerebral Palsy Children Reviewed from the Family Counseling. In *5th International Conference on Education and Technology (ICET 2019)* (pp. 700-702). Atlantis Press.
<https://doi.org/10.2991/icet-19.2019.169>.
- Sakhaei, F., Golmohamadi, G., & Rezaei, M. (2019). Investigation of feeding problems in children with cerebral palsy. *Journal of Otolaryngology-ENT Research*, 11(1), 56-8.
<https://doi.org/10.15406/joentr.2019.11.00410>.
- Tambunan, R. M., Lubis, D. P., Muljono, P., & Puspitawati, H. (2023). Family Member Communication For Spastic Cerebral Palsy Parenting Literatur Review. *International Journal of Science, Technology & Management*, 4(3), 640-652.
<https://doi.org/10.46729/ijstm.v4i3.812>.
- Tofani, M., Blasetti, G., Lucibello, L., Sabbadini, M., Berardi, A., Galeoto, G., ... & Castelli, E. (2021). Seated postural control measure: Italian translation and validation in children with cerebral palsy. *Prosthetics and Orthotics International*, 45(5), 378-383.
<https://doi.org/10.1097/pxr.0000000000000033>.
- World Health Organization. (2001). International Classification of Functioning, Disability and Health (ICF). Retrieved December 2, 2024 from <https://www.who.int/standards/classifications/international-classification-of-functioning-disability-and-health>.
- Zhao, J., Liu, Y., Su, J., Sun, G., & Xie, H. (2024). The Impact of Tele-Rehabilitation Nursing on the Daily Living Abilities of Children with Cerebral Palsy. *Pacific International Journal*, 7(3), 121-125.
<https://doi.org/10.55014/pij.v7i3.631>.
- Zukić, A., Hadžić, D., Kuduzović, E., Alibegović, D. R., Kurtić, A., & Avdić, B. (2021). Activities Of Daily Life of Children and Youth with Cerebral Palsy. *Research in Education and Rehabilitation*, 4(2), 156-164.
<https://doi.org/10.51558/2744-1555.2021.4.2.156>.