Domestic Safety Evaluation of Upright Posture Device Tools for Children with Cerebral Palsy in Malaysia

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Abstract

The advancement of secure and efficacious assistive technologies is crucial for enhancing the quality of life and autonomy of children with disabilities. This research tackles the essential requirement within the Malaysian setting, concentrating primarily on upright posture device tools (UPDT) for children with cerebral palsy. Children with cerebral palsy frequently have difficulties in executing daily tasks autonomously due to restricted physical activity, rendering dependable assistive devices crucial for improving their mobility and general quality of life. The main aim of this study is to thoroughly assess the safety, stability, and durability of UPDTs, confirming their suitability for residential applications. Assessments were undertaken at the FITEC Furniture Testing Centre (FFTC) to evaluate the structural integrity and general safety of each equipment, utilising established standards such as BSEN 12520:2015, BSEN 1022:2005 and BSEN 1728:2012. Significant insights were revealed as the results demonstrated the absence of fractures or failures in joints and components, with all stiff joints maintaining stability under stress. Moreover, the devices satisfied stability criteria during weight-bearing assessments, validating their durability. This study supplies essential data to advise UPDT safety standards and presents practical design recommendations for improving assistive device security. Ultimately, our findings endorse the ongoing development of UPDTs, enhancing the welfare of children with disabilities and their families. Subsequent studies should build upon these findings to assess the effectiveness of UPDTs in enhancing health and functional autonomy in younger users.

Keywords: Assistive Devices, Cerebral Palsy, Domestic Safety Test, Rehabilitation Tools, Upright Posture Device Tools

1.0 Introduction

The necessity for secure and efficient assistive devices is becoming increasingly crucial in tackling the obstacles encountered by children with impairments [1] and [2] stated that people with disabilities have a greater need for healthcare on average, but often face barriers when accessing these services. [1]. Six studies focused on the importance of assistive technology to promote quality of life, and three studies highlighted the need to expand the availability of assistive technologies in the public health system. Meaning, there is a lack in providing suitable devices to children with impairments.

Children with cerebral palsy, a neurological disorder impacting mobility and coordination, frequently encounter considerable restrictions in their physical activities relative to their typically developing counterparts [3]. This gap can impede their capacity to execute daily chores autonomously, adversely affecting their overall quality of life [4]. Consequently, the creation of dependable support equipment, including upright posture device tools (UPDT), becomes essential. Previous studies [5], [6] these devices not only enable mobility but also significantly contribute to fostering physical activity, enhancing postural control, and improving the overall well-being of children with cerebral palsy. Nevertheless, numerous current technologies may inadequately meet the particular requirements of these children for safety, stability, and endurance. The lack of thorough testing standards and norms for home usage generates apprehensions over potential hazards linked to these devices, hindering their adoption and efficacy [7]. As a result, there is an imperative requirement for comprehensive assessment and enhancement of UPDTs to guarantee their appropriateness for children with impairments in practical environments.

This study seeks to thoroughly assess the safety, stability, and durability of UPDTs, confirming their suitability for residential applications [8]. The research aims to give a clear evaluation of the overall structured strength of the UPDTs. This study's distinctive component is its thorough evaluation of UPDTs specifically tailored for children with cerebral palsy. Using established standards [9] like BSEN 12520:2015, BSEN 1022:2005 and BSEN 1728:2012, the study examines the mechanical characteristics of these devices as well as how they are used in daily life. This dual emphasis guarantees that the results are pertinent and implementable, underscoring the necessity for devices capable of enduring the demands of everyday use while prioritising user safety [10].

The results of this study provide useful information that can drive the creation of UPDT safety standards and guidelines to improve adaptive technology design and production. The study shows that the evaluated devices fulfil safety and stability requirements. Hence, facilitating the further enhancement of UPDTs and improving the quality of life for children with disabilities and their families [11]. The study establishes a foundation for future research to examine the effectiveness of UPDTs in enhancing health, functional independence and general well-being in young users, thereby promoting a more inclusive environment for children with disabilities [12].

The necessity for secure and efficient assistive devices is becoming increasingly critical in tackling the obstacles encountered by children with impairments [13]. This study investigates the domestic safety of Upright Posture Device Tools (UPDT) specifically intended for children with impairments in Malaysia, particularly those diagnosed with cerebral palsy [14], [15]. Children with cerebral palsy generally participate in reduced physical activity compared to their peers, hindering their capacity to execute daily activities autonomously [16], [17]. As a result, young children frequently encounter considerable restrictions in their physical activities, adversely affecting their overall quality of life [18]. The device aims to enhance physical activity in youngsters, targeting the reduced exercise levels commonly seen in those with cerebral palsy, as referred to the European Committee for Standardisation [19]. A detailed testing protocol was devised to assess the structural stability, strength, durability and overall safety of these devices.

2.0 Methodology

In this article, the aim is to focus on laboratory tests to evaluate the stability, strength, and durability of a single Upright Posture Device (UPDT) prototype unit. UPDT prototype has undergone safety testing in domestic test settings, which is under the supervision and testing of MS ISO/IEC 17025 for a duration of one month. In compliance with the ISO Standard [20], this furniture testing laboratory (FTL) provides thorough evaluation services. Each test was conducted continuously for a full day, and the load values were determined using the test category and conditions specified in Table 1. To make sure the Upright Posture Device Tool (UPDT) is safe, stable and dependable for use by children with cerebral palsy at home, it underwent extensive testing using three recognised international furniture standards. The device was tested for strength and durability in accordance with BS EN 12520:2015 by applying loads to the seat and backrest (600N and 20N, respectively). It was also examined for any potentially dangerous components or sharp edges. In order to ensure that the device would not topple forward, sideways, or backwards under normal use, especially in the absence of armrests, BS EN 1022:2005 placed a strong emphasis on stability. Last but not least, in order to test its capacity to withstand impact, BS EN 1728:2012 replicated long-term use by exerting pressure repeatedly up to 1,000N on the seat and 800N on the seat edge over 20,000 cycles and dropping a 25 kg weight. These evaluations assure that the UPDT is secure and long-lasting enough to assist kids in typical home environments while also reflecting real-world difficulties. The upright posture device's safety testing complies with the Standards for Domestic Safety [20].

Table 1: Domestic safety tests

<table>
<tr><td colspan="2">1. BS EN 12520:2015 - Furniture Strength, Durability, and Safety Requirements for Domestic Seating. This standard ensures the upright posture device is robust, durable, and safe for domestic use.
Requirement: Load: 600N (seat), 20N (backrest), no armrests.</td></tr>
<tr><td>Purpose</td><td>Method</td></tr>
<tr><td>i) Strength Testing</td><td>a) Static Load Test: Assess the device's ability to endure weight without incurring damage by testing the seat, back, and arms. Apply standard weights to each part of the device in accordance with the instructions.
b) Impact Test: To evaluate the device's capacity to withstand unexpected forces, perform an impact test by releasing a designated weight onto the seat from a predetermined height to examine structural integrity.</td></tr>
<tr><td>ii) Durability Testing</td><td>a) Fatigue Test: Cyclic stresses are constantly applied to the seat, back, and arms to simulate prolonged usage. Examine for indications of deterioration or dysfunction following multiple cycles.
b) Leg Strength Test: Evaluate the robustness of the leg components by applying horizontal and vertical forces to measure their endurance under standard usage conditions.</td></tr>
<tr><td>iii) Safety Testing</td><td>a) Sharp Edges and Protrusions: To guarantee user safety, examine for sharp or protruding elements and confirm that all edges are smooth and rounded.
b) Entrapment Hazards: To avert injury, inspect for any possible entrapment sites for fingers, hands, or other body parts.</td></tr>
<tr><td colspan="2">2. BS EN 1022:2005 – Furniture Seating: Determination of Stability. This standard ensures the device remains stable and safe in various conditions.
Requirement: Load: 600N (seat), 20N (backrest), no armrests.</td></tr>
<tr><td>Purpose</td><td>Method</td></tr>
<tr><td>i) Stability Testing</td><td>a) Forward Stability Test: Examine the device's forward stability to avoid forward tipping.
b) Horizontal Stability Assessment: Apply force to the device's side to evaluate its resistance to tipping.
c) Rearward Stability Test: To assess backward stability, incline the device's front edge and confirm it maintains stability under rearward force.</td></tr>
<tr><td colspan="2">3. BS EN 1728:2012 – Furniture Seating Test: Methods for Determination of Strength and Durability. This standard ensures the upright posture device is strong, durable, and safe for long-term use.
Requirement:
Seat and Back Fatigue: 1000N (seat), 300N (backrest)
Seat Edge Fatigue: 800N, 20,000 repetitions
Seat impact: 25kg dropped from 180 mm</td></tr>
<tr><td>Purpose</td><td>Method</td></tr>
<tr><td>i) Strength Testing</td><td>a) Seat and Back Static Load Test: Evaluate the load-bearing capacity of the seat and backrest by confirming their support of designated weights for specified durations.
b) Leg Strength Assessment: To evaluate leg strength, exert horizontal and vertical pressures.</td></tr>
<tr><td>ii) Durability Testing</td><td>a) Seat and Back Fatigue Test: To replicate frequent usage, apply cyclic loads to the seat and backrest, reporting any indications of wear following a specified number of repetitions.
b) Armrest Fatigue Test: Evaluate durability by subjecting the armrests to repeated loading and monitoring for any signs of failure.</td></tr>
<tr><td>iii) Safety Testing</td><td>a) Leg Forward and Backwards Load Test: To verify leg stability, apply controlled forces on the legs.
b) Seat Impact Test: To assess structural integrity, release a designated weight from a predetermined height onto the seat.</td></tr>
</table>

The laboratory setting is one of the additional elements taken into account throughout the domestic testing procedure: To guarantee the device's safety and performance in a range of home settings, testing must be conducted under a wide range of environmental circumstances, including variations in temperature and humidity, as they will affect the laboratory test (controllable lab test requirement). The setup for the Furniture Testing Laboratory (FTL) of the Furniture Industry Technology Centre (Fitec) is depicted in Figure 1. A qualified executive technician from Fitec administered the test.

Figure 1: Furniture Testing Laboratory (FTL) is being conducted by FITEC Furniture Testing Centre (FFTC)

2.1 Method of Testing

Several mechanical tests were performed on the ergonomic chair prototype in compliance with the following guidelines, which are BS EN 12520:2015, BS EN 1022:2005 and BS EN 1728:2012. In order to replicate normal domestic seating conditions, all tests were carried out without armrests. The tests were designed to evaluate the seat and backrest components' fatigue durability, impact resistance, stability and static strength. These are the methods of testing that were employed, and the testing procedure is as follows.

i. Seat Impact Test

This test mimics dynamic loading brought on by a user abruptly sitting down in accordance with BS EN 12520:2015. From a height of 180 mm, a 25 kg mass was dropped onto the seat surface. The chair was inspected for post-impact instability, irreversible deformation and structural failure. Figure 2 shows the seat impact test conducted in the laboratory.

Figure 2: Seat impact test

ii. Forward Overbalancing Test

This test, which was carried out in accordance with BS EN 1022:2005, assessed the chair's resistance to tipping forward. To replicate normal user posture, a 600 N vertical load was applied to the seat's front edge, and a 20 N load was applied to the backrest at the same time. We looked for any indications of forward overbalancing in the chair. Figure 3 shows a forward overbalancing test conducted in the laboratory.

Figure 3: Forward overbalancing test

iii. Sideways Overbalancing Test (Without Armrests)

This test evaluated the chair's lateral stability in compliance with BS EN 1022:2005. To replicate unbalanced seating conditions, asymmetrical weights were applied. It was necessary for the prototype to withstand these loads without toppling over. Figure 4 shows a sideways overbalancing test conducted in the laboratory.

Figure 4: Sideways overbalancing test

iv. Seat Front Edge Static Load Test

A 600 N static load was applied vertically to the seat's front edge in accordance with BS EN 1728:2012. The purpose of this test was to assess the seat's structural integrity under static pressure. The structure's deflection and failure indicators were evaluated. Figure 5 shows the seat front edge static load test conducted in the laboratory.

Figure 5: Seat front edge static load test

v. Seat Front Edge Fatigue Test

This cyclic test mimicked long-term use and was also based on BS EN 1728:2012. A pneumatic actuator was used to apply a repetitive 800 N load vertically to the front edge of the seat. In order to evaluate fatigue performance and material endurance, the test was run over 20,000 cycles. Figure 6 shows the seat front edge static load test conducted in the laboratory.

Figure 6: Seat front edge static load test

3.0 Results and Discussion

The Upright Posture Device Tool (UPDT) underwent extensive testing in compliance with international furniture safety standards to verify its stability, durability and domestic safety. A concise synopsis of the safety tests, test conditions and results is given in Table 2.

Table 2: Summary of domestic safety test results

Standard	Test Type	Applied Load / Condition	Duration / Cycles	Outcome
BS EN 12520:2015	Edge Safety & Sharp Elements	Visual inspection and tactile check	Single inspection	All user-contact surfaces were rounded or chamfered. No burrs or sharp edges detected. Upholstery adds further protection.
	Component Integrity	Check hollow components and motorised parts	Single inspection	Hollow components capped. Motorised adjustable parts are fully enclosed and safe.
BS EN 1022:2005	Forward & Side Stability	600N (seat), 20N (backrest), no armrests	Once every 5 seconds for 24 hours	No tipping or overturning. The prototype fulfilled BS EN 1022 standards.
BS EN 1728:2012	Seat and Back Fatigue	1000N (seat), 300N (backrest)	24 hours (10 sec holds)	No damage observed; structure remained stable.
	Seat Edge Fatigue	800N, 20,000 repetitions	2 sec per force	Passed without deformation or joint loosening.
	Seat Impact	25kg dropped from 180mm	10 repetitions	No cracks or visible damage. Structural integrity retained.

Test circumstances for the UPDT prototype included room temperatures between 22°C and 30°C and humidity levels between 55% and 75%, which are typical of Malaysian homes. The performance and safety of the device were not significantly impacted by these environmental conditions. However, there are some restrictions to be considered. The results may not accurately reflect how the device would function over time in real-life scenarios because the testing was conducted in controlled laboratory conditions. Additionally, because only one prototype was evaluated, the results may not be generalizable. This phase did not include long-term field testing that may demonstrate how the device continues to function after months or years of regular use. However, the prototype outperformed comparable systems emphasised in previous research, particularly concerning its robustness and the safety of its motorised modifications. It was simpler to control with the inclusion of a motorised system, which decreased physical strain and the possibility of unexpected motions. Above all, the device complied with all major durability and safety requirements (BS EN 1022:2005, BS EN 1728:2012 and BS EN 12520:2015). The UPDT is a useful, secure and easy-to-use technology that can genuinely assist children with cerebral palsy in their everyday life at home as a rehabilitation exercise. The researchers hypothesised that, in comparison to comparable rehabilitation tools available on the market, UPDT might make it possible to satisfy the patient's needs, especially in improving upright posture, condition and surroundings. Enhancing their capacity to engage in activities and improving their general quality of life are the objectives of rehabilitation exercise utilising assistive devices such as UPDT [21], [22].

4.0 Conclusion

This study assessed an Upright Posture Device Tool (UPDT) prototype for children with cerebral palsy in domestic settings for functionality, durability, and safety. In accordance with BS EN 12520:2015, BS EN 1022:2005 and BS EN 1728:2012 standards, the device was subjected to extensive mechanical testing. The prototype met all necessary safety and stability requirements, according to the results. Under conditions similar to those of home use, it demonstrated strong fatigue resistance, structural integrity and no mechanical failure. Furthermore, environmental testing revealed no negative effects on performance, and caregiver feedback validated the device's comfort and usability. These results support the UPDT's potential as a workable assistive technology to help kids with disabilities with their postural and mobility transitions. The study's conclusions offer parents and rehabilitation designers vital resources when looking for the best assistive technology options for their kids. To solve the issue of erratic movements during positional transitions, future advancements in motorised and surveillance systems are needed. Fixing this problem is crucial to maximising the UPDT's functionality and promoting a more reliable and effective way to increase the mobility and independence of kids with disabilities. Future studies could look into possible commercialisation tactics, such as partnerships with medical facilities and rehabilitation facilities, to enable broader access to this special technology. Encouraging commercialisation will make UPDTs more widely accessible to families and caregivers looking for suitable, supportive solutions for children with disabilities in enhancing their lives.

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Author Contributions

Fatimahwati Hamzah: Conceptualisation, Methodology, Validation, Investigation, Data Curation, Resources, Formal Analysis, Writing-Original Draft, Writing-Review & Editing; **Sazlina Kamaralzaman and Saiful Hasley Ramly**: Supervision, Project Administration, Data Curation, Investigation, Resources; **Intan Suria Hamzah and Mohd Fakhrul Azri Abdullah**: Visualisation, Writing–Review & Editing.

Conflicts of Interest

The manuscript has not been published elsewhere and is not under consideration by any other journal. All authors have reviewed and approved the manuscript, agree with its submission, and declare that there are no conflicts of interest.

References

[1] G. Jansheki, "Assistive Technology and Adaptive Equipment for Children with Cerebral Palsy," 2023. [Online]. Available: cerebral-palsy/living/assistive-technology/.

[2] M. Cunha, H. Santos, M. Carvalho, G. Miranda, M. Albuquerque, R. Oliveiraet al., "Health care for people with disabilities in the unified health system in Brazil: A scoping review", International Journal of Environmental Research and Public Health, vol. 19, no. 3, p. 1472, 2022. https://doi.org/10.3390/ijerph19031472

[3] Hamzah and S. H. Ramli, "A Systematic Review of Assistive Technology Devices to Promote Independent Living in Children with Cerebral Palsy," in Proceedings of the 2nd International Conference on Design Industries & Creative Culture, DESIGN DECODED 2021*, Kedah, Malaysia, Mar. 2022.*

[4] R. Amritha and S. Akila, "Design and development of an adaptive chair for children with motor disabilities," 2021.

[5] F. Hamzah, I. S. Hamzah, and N. Misduki, "Development of 3-in-1 SFs for Children with CP in Malaysia," *E-PROCEEDING*, vol. 8, 2021.

[6] M. Jackman *et al.*, "Interventions to improve physical function for children and young people with cerebral palsy: international clinical practice guideline," *Developmental Medicine & Child Neurology*, vol. 64, no. 5, pp. 536–549, Sep. 2021.

[7] C. R. Sundaresan, V. Thirupathirao, and V. R. Naik, "Cerebral palsy is a group of conditions affecting movement," 2022. [Online]. Available: https://www.thestar.com.my/lifestyle/health/2022/07/07/cerebral-palsy-is-a-group-of-conditions-affecting-movement.

[8] D. Ciarmoli, "Assistive Technology to Promote Adaptive Skills in Children and Adolescents with Rett Syndrome: A Selective Review," in *Assistive Technologies for Assessment and Recovery of Neurological Impairments*, F. Stasolla, Ed. IGI Global, 2022, pp. 131–146, doi: 10.4018/978-1-7998-7430-0.ch007.

[9] M. Pashmdarfard, L. G. Richards, and M. Amini, "Factors Affecting Participation of Children with Cerebral Palsy in Meaningful Activities: Systematic Review," *Occupational Therapy in Health Care*, vol. 35, no. 4, pp. 1–38, Jun. 2021, doi: https://doi.org/10.1080/07380577.2021.1938339.

[10] M. A. Abdallah, F. Abdelaziem, and M. Soliman, "Prevalence of the need for adaptive seating systems among children with cerebral palsy in Egypt," *Prosthetics & Orthotics International*, vol. 46, no. 1, pp. 7–11, Nov. 2021, doi: https://doi.org/10.1097/pxr.0000000000000065.

[11] F. Hamzah *et al.*, "A New Modification of 3 in 1 Standing Frame for Children with Cerebral Palsy," *Jurnal Kejuruteraan*, SI 6(2), pp. 73–84, 2023.

[12] J. A. Buitrago, A. M. Bolaños, and E. C. Bravo, "A motor learning therapeutic intervention for a child with cerebral palsy through a social assistive robot," *Disability and Rehabilitation: Assistive Technology*, vol. 15, no. 3, pp. 357–362, 2020.

[13] R. Inthachom *et al.*, "Evaluation of the multidimensional effects of adaptive seating interventions for young children with non-ambulatory cerebral palsy," *Disability and Rehabilitation: Assistive Technology*, vol. 16, no. 7, pp. 780–788, 2021.

[14] S. L. Saavedra and A. D. Goodworth, "Postural Control in Children and Youth with Cerebral Palsy," in *Cerebral Palsy*, F. Miller, S. Bachrach, N. Lennon, and M. O'Neil, Eds. Springer, Cham, 2019.

[15] W. R. G. Wan Abdul Ghafar, M. F. Ahmad, and N. Yahya, "Challenges Experienced by Mothers of Children with Cerebral Palsy during the Movement Control Order (lockdown) in Malaysia: A Qualitative Study," *Journal of Nusantara Studies (JONUS)*, vol. 8, no. 1, pp. 246–269, 2023.

[16] M. Towns, S. Lindsay, K. Arbour-Nicitopoulos, A. Mansfield, and F. V. Wright, "Balance confidence and physical activity participation of independently ambulatory youth with cerebral palsy: an exploration of youths' and parents' perspectives," *Disability and Rehabilitation*, vol.

44, no. 11, pp. 1–12, Nov. 2020, doi: https://doi.org/10.1080/09638288.2020.1830191.

[17] M. Abid, Y. Cherni, C. S. Batcho, E. Traverse, M. D. Lavoie, and C. Mercier, "Facilitators and barriers to participation in physical activities in children and adolescents living with cerebral palsy: a scoping review," *Disability and Rehabilitation*, vol. 45, no. 25, pp. 1–16, Nov. 2022, doi: https://doi.org/10.1080/09638288.2022.2150327.

[18] A. J. Molina-Cantero *et al.*, "A Study on Physical Exercise and General Mobility in People with Cerebral Palsy: Health through Costless Routines," *International Journal of Environmental Research and Public Health*, vol. 18, no. 17, p. 9179, 2021.

[19] European Committee for Standardization, *BSEN 12520:2015 - Furniture: Strength, Durability, and Safety - Requirements for Domestic Seating*. Brussels: CEN, 2015.

[20] ISO, "ISO/TC 173/SC 7 Assistive products for persons with impaired sensory functions," [Online]. Available: https://www.iso.org/standards.html. 2024

[21] H. I. Sarsak, "Patient Satisfaction with Occupational Therapy Services for Wheeled Mobility and Seating Devices," *Occupational Therapy In Health Care*, pp. 1–14, Sep. 2022, doi: https://doi.org/10.1080/07380577.2022.2121992.

[22] Q. Chu *et al.*, "A Thematic Review of Design Factors that Contribute to the Perceived Stigma Associated with Assistive Technology," *Springer series in design and innovation*, pp. 463–475, Jan. 2024, doi: https://doi.org/10.1007/978-3-031-60863-6_36.