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Cerebral Palsy Child Seat: Ergonomic Consideration

Fatimahwati bt Hamzah[1], Norshahanis bt Hashim[2], Nafizah bt Hassan[3], Nurin bt Hafilah Hamzah[4], Tg.Nur Syarah Bariah bt Raja Mohd Yazit[5], Rafidah Farah Hanim bt Abdul Razak[6], Hamdi b. Mawardi[7]

[1] *Civil Engineering Department, Politeknik Sultan Salahuddin Abdul Aziz Shah, Selangor, Malaysia*
[2] *Civil Engineering Department, Politeknik Sultan Salahuddin Abdul Aziz Shah, Selangor,Malaysia*
[3] *Civil Engineering Department, Politeknik Sultan Salahuddin Abdul Aziz Shah, Selangor,Malaysia*
[4] *Civil Engineering Department, Politeknik Sultan Salahuddin Abdul Aziz Shah, Selangor,Malaysia*
[5] *Civil Engineering Department, Politeknik Sultan Salahuddin Abdul Aziz Shah, Selangor,Malaysia*
[6] *Civil Engineering Department, Politeknik Sultan Salahuddin Abdul Aziz Shah, Selangor,Malaysia*
[7] *Civil Engineering Department, Politeknik Sultan Salahuddin Abdul Aziz Shah, Selangor,Malaysia*

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ABSTRACT

Cerebral Palsy (CP) is a term used to describe a disorder usually caused by brain damage occurring at or before birth and marked by muscular impairment. Often accompanied by poor coordination, it sometimes involves speech and learning difficulties [1]. The objective of this research is to determine the suitable design for developing the Cerebral Palsy Child seat and to evaluate the product safety. From the information given by doctor, clinicians and occupational therapist at Occupational Therapy (OT) clinic, Universiti Kebangsaan Malaysia (UKM), Kuala Lumpur the special equipment or aids for CP children in Malaysia were very limited. They need an appropriate seating equipment, to provide an optimal seated position to improve their functional activities. CP Child Seat is one of the assistive devices that help the CP child to be seat in a correct posture or position. The development of CP Child Seat was based on the Universal Corner Chair at OT clinic, UKM, KL as a guideline. The methodology of this study includes survey, observation, measurement of anthropometry data and data analysis. From this study, it can be concluded that CP Child Seats have been successful developed based on doctor, therapist, clinician and parents' requirement. Design 4 is more preferable by the respondent compared to other designs, but the safety aspect should be improved as recommended by Forest Research Institute of Malaysia (FRIM**).**

INTRODUCTION

The appropriate seating equipment for children with CP is very important, in order to provide an optimal seated position for their routine activities. [2] Stated that because postural and motor control problems are the main problem faced by students with CP, they will often spend more time sitting rather than standing during their day, both at school and at home. It is vital that their adaptive seating provides positioning that is optimal for both health and function. Research paper done by [3] stated that the benefits of adaptive seating is to improved postural alignment, development of motor skills, helping the prevention of fixed deformity and facilitation of upper extremity function. Normal positioning is achieving by an upright symmetrical posture utilising the 90-90-90 flexion at the hips, knees and ankles position. Although an important posture to achieve, this upright position is suggested as non-functional and difficult to maintain all the time, resulting in adoption of compensatory postures which may lead to long term deformity and further deterioration when appropriate external support is not provided. Seating solutions may require reaching a balance between an upright anatomical symmetrical posture and ability

to function. There are no regular chairs design to give more support or special positioning in market nowadays. Corner-Chair is an absolutely chair that commonly used because of it has a specific size. This chair can avoid the CP children from laying down the whole day [4]. Therefore this present paper aims at giving an overview of the understanding knowledge of children with CP. Special attention is paid in designing the CP Child Seats in terms of seating and positioning to support their spine, make it mobile and ergonomic to promote long term health and functional independence. The main objective of this research paper is to determine the suitable design for developing the CP Child Seats and to evaluate the product safety.

PROBLEM STATEMENT

Based on the information gathered from OT clinic, UKM, KL, the numbers of available corner chair in the local market cannot accommodate the numbers of patients, it is costly because it has to be custom made and ordered from overseas. In Malaysia, there are a few Medical centre provide the special seat for CP children. The existing corner chair in the market has to be upgraded because the product is not mobile, the product size does not suit with Malaysian CP children, the seat does not support the patient's condition, and the stopper is not adjustable. Therefore, this study was carried out to produce a special seat for CP children in Malaysia with an ergonomic consideration.

LITERATURE REVIEW

(a) Cerebral Palsy

Cerebral Palsy (CP) can be defined as non-progressive abnormality of the developing brain that result in neurological, motor and postural deficits in the developing child [3]. [4] Stated that CP means “brain paralysis”. It is a disability that affects movement and body position. It comes from brain damage that happened before the baby was born, at birth, or as a baby. The whole brain is not damaged, mainly parts that control movement. Once damaged, the parts of the brain do not recover, nor do they get worse. But the movements, body positions and related problems can be improved or made worse depending on how the CP children get treatment and how damaged his or her brain happens to be. In Malaysian population of 24 million, there are about 800,000 children with some form of disability includes CP that requires special care and out of 8.1% are from CP children.

There are several types of CP problems such as Spastic, Athetoid (Dyskinetic), Ataxic and etc. “Spastic” means stiff and these forms of CP stiffens muscles and decrease the range of movements in joints. Someone with spastic CP has to work harder to walk or move. People with “Athetoid” CP make involuntary movements, because their muscles rapidly change from floppy to tense in a way they cannot control. Their speech can be hard to understand because they have difficulty in controlling their tongue, breathing and vocal cords. Hearing problem also existed. People with “ataxic” CP find it very difficult to balance. They may have poor spatial awareness. This means it is difficult for them to judge their position relative to other things around them [4].

CP cannot be cured, so the children will probably need lifelong treatment. Treatments can help dealing with symptoms, prevent problems, and improve most of children's abilities. Physical therapy is one of the most important treatments. Other than that, medicines, surgery, and special equipment such as walker, standing equipment, transfer aids and parallel bar might be help them in treatments.

(b) Anthropometry Data for Children

Anthropometry in physical anthropology refers to the measurement of the human individual for the purposes of understanding human physical variation. In designing the special chair or seats for children with disabilities, physical and ergonomic aspects need to be focused. Table 1 shows the anthropometric data for male and female [4].

Table 1: Percentile value of anthropometric data for male and female children.

MALE					
Measurement (cm)	Mean	Std	95th %tile	50th %tile	5th %tile
1. Sitting Measurements					
a) Shoulder breadth	29.88	8.99	44.62	29.88	15.14
b) Hip breadth	23.71	2.58	27.94	23.71	19.48
c) Arm reach forward	55.33	5.65	64.60	55.33	46.06
d) Forearm- Hand Length	34.67	4.79	42.53	34.67	26.81
e) Buttock-knee length	37.58	4.30	44.63	37.58	30.53
f) Buttock-popliteal Length	33.50	4.93	41.59	33.50	25.42
g) Sitting Height	98.17	8.96	112.86	98.17	83.48
h) Eye Height	87.67	7.74	100.36	87.67	74.98
i) Shoulder Height	76.33	5.87	85.96	76.33	66.70
j) Shoulder-Elbow Length	24.17	3.80	30.40	24.17	17.94
k) Knee Height	39.92	4.56	47.40	39.92	32.44
l) Popliteal Height	35.08	4.23	42.02	35.08	28.14
2. Surface Measurements					
a) Interscye breadth	29.79	11.35	48.40	29.79	11.18
b) Back Waist Length	27.50	4.64	35.11	27.50	19.89
c) Sleeve Inseam	45.83	9.16	60.85	45.83	30.81
3. Hand Measurements					
a) Palm Length	13.00	3.01	17.94	13.00	80.64
b) Span	222.15	10.21	238.89	222.15	205.41

FEMALE						
	Measurement (cm)	Mean	Std	95th %tile	50th %tile	5th %tile
1.Sitting Measurement						
a	Shoulder breadth	29	2.9	33.76	29	24.24
b	Hip breadth	22.93	2.92	27.72	22.93	18.14
c	Arm reach Forward	55.86	3.81	62.11	55.86	49.61
d	Forearm-Hand Length	34	2.65	38.35	34	29.65
e	Buttock-Knee Length	37.43	3.21	42.69	37.43	32.17
f	Buttock-poplitel Length	34.71	3.59	40.6	34.71	28.82
g	Sitting Height	100.14	6.04	110.05	100.14	90.23
h	Eye Height	90.71	5.71	100.08	90.71	81.35
i	Shoulder Height	78.49	3.95	84.97	78.49	72.01
j	Shoulder -Elbow Length	24.57	3.6	30.47	24.57	18.67
k	Knee Height	41.57	3.14	46.72	41.57	36.42
l	Poplitel Height	36.29	2.5	40.39	36.29	32.19
2. Surface Measurements						
a	Interscye Breadth	29	3.06	34.02	29	23.98
b	back Waist length	28.14	4.31	35.21	28.14	21.07
c	Sleeve Inseam	46.57	8.64	60.74	46.57	32.4
3. Hand Measurement						
a	Palm Length	11.4	3.49	17.12	11.4	5.68
b	Span	113.14	15.9	139.22	113.14	87.06

(c) Ergonomic

According to [4], ergonomics or human factors is the scientific discipline concerned with the understanding of interactions among humans and other elements of a system, and the profession that applies theory, principles, data and methods to design in order to optimize human well-being and overall system performance. Human factor and ergonomic is employed to fulfil the goals of occupational health and safety and productivity. It is relevant in the design of such things as safe furniture and easy-to-use interfaces to machines and equipment. Proper ergonomic design is necessary to prevent repetitive strain injuries and other musculoskeletal disorders, which can develop over time and can lead to long-term disability [5].

(d) Ergonomic Design

Ergonomic is the design-oriented discipline. However, as discussed by [5], ergonomists do not design system; somewhat human factor ergonomic professionals design the interaction between the object system and humans. One of the fundamental problems involved in such a design is that typically there are multiple functional system- human compatibility requirements that must be satisfied at the same time.

(e) Ergonomic For the Need of Rehabilitation

At present there appears a new direction of ergonomics aims at the needs of disable people. This rehabilitation ergonomics [6], [7] and [8] roughly defined as an interdisciplinary field of science that aims at adjusting tools, machines, equipment and technologies as well as material work and life environments including objects of daily use and rehabilitation equipment to the psychophysical needs of the disabled. Rehabilitation ergonomics takes part both in the rehabilitation process and equalizing chances [5].

As ergonomics develops and compliance with its needs, anthropometry develops new method that can be called ergonomic anthropometry. The rehabilitation ergonomic anthropometrics can be divided into two parts:

- The first part is strictly connected with ergonomics, where anthropometry provides data for designing and shaping work and life environment of the disable.
- The second part embraces all methods and measuring techniques that assist the rehabilitation process.

(f) Workspace Measurements.

Essential characteristics exerting an influence on workspace shaping are functional characteristics of the upper extremities that is reaches. Values observed in these characteristics are significantly lower in persons with the lower extremities dysfunction, although their upper extremist are qualified as efficient. Lower values of reaches result not only from lower value of the arm and forearm length, but also from limitations in shoulder and elbow joints. In connection with the above, the disabled have difficulty in performing the movements of abduction and extension [9].

(g) Seating and Positioning

From a biomechanical viewpoint, good posture is dependent on the balance of the skeleton and symmetrical alignment of body segments. [10] Stated that those who balance their body in accordance with mechanical rules for human body systems (laws of physics) tend to be more erect. From a neurophysiological and developmental perspective, normal posture is also dependant on the development of normal postural control which is described as the control of the bodies' position in space in order to obtain stability and orientation [11] and is influenced by the neuromotor, somatosensory, vestibular and musculoskeletal systems [12]. Postural control requires achieving normal developmental milestones and includes the development of postural reactions (righting, protective and equilibrium reactions), developmental integration of primitive reflexes (asymmetrical tonic neck reflex, symmetrical tonic neck reflex, and tonic labyrinth reflex), normal muscle tone, normal postural tone and intentional voluntary movements [13].

(h) Seating and Postural Implications

[4] Stated that an appropriate seated positioning aims to have a beneficial effect on tone, reflex activity, prevention of deformity, maintenance of skin and tissue intergrity, postural stability, alignment, and optimizing function. Besides, an appropriate positioning while in adaptive seating can have impact on the pulmonary function of children with CP, with implications for capacity for speech and overall lung health. Children with CP will have difficulty with stationary postures, transitionary movements and functional mobility [14]. Literature suggests that appropriate seating should aim to normalise tone, inhibit reflex activity, prevent deformity, promote optimal function, maintain postural alignment, maintain tissue integrity and maximise stability [15]. The provision of adaptive equipment to children with CP should be individualised based on functional and contextual factors. Disparity in the literature exists regarding the optimal sitting position for a children with CP. Some authors advocate the upright posture [16], [17] and [18] and there are those that advocate a reclined posture [19] and [20] to enhance postural control. It is recognised that some of these studies do not refer to cerebral palsy as a heterogeneous group. Though more research is needed, the evidence across studies suggests that seat inclinations can affect function. However, the angle of seat incline or tilt found to enhance function varies between studies and between children with different types of cerebral palsy. Research has not been conclusive that any one position is necessarily more effective than others for improving sitting posture and active function. Research further suggests that a straddled or saddle-seat posture (with hips abducted and externally rotated, and a forward seat slope, facilitating anterior tilt of the pelvis with dynamic weight-bearing through the lower extremities) may improve postural control [4].

METHODOLOGY

The methodology of this study includes survey, observation, measurement of anthropometry data and data analysis.

(a) Observation and Survey

The observations and survey have been made on CP children behavior towards the utilization of existing Universal Corner Chair at OT clinic, UKM, KL. This clinic provides health care services and have special clinics for children and adolescents who carry out screening for children with developmental problems (developmental delay), learning disabilities such as Dyslexia, Autism and ADHD (Attention deficit-hyperactivity disorder). Questionnaires were given to 10 parents with CP children, to determine the suitable design from the four proposed design. The questionnaire has been analysing by using Microsoft Excel software.

(b) Subjects

The subject of this study was a boy aged 6 years old. The sample has been identified having a Cerebral Palsy in Quadriplegia category which means all four limbs are involved.
Figure 1 shows the types of Cerebral Palsy.

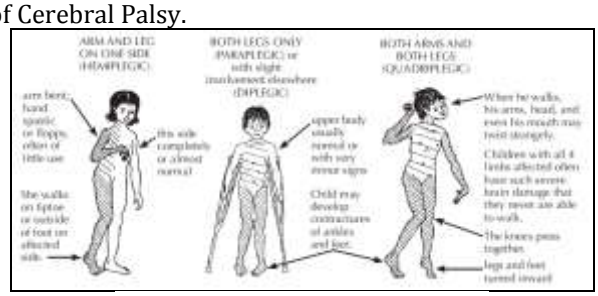


Figure 1: Types of Cerebral Palsy

(c) Anthropometry Data

For anthropometric data, the sample was chosen by occupational therapist based on his ability to perform the task. The measurement physical body of the sample were provided from OT clinic, UKM, KL.

Table 2: The physical body measurement of the sample

Description	Measurement (mm)
Height neck to head	200
Shoulder length	240
Waist width	150
Waist to knee	250
Waist to toe	460
Armpit to waist	290
Armpit to stomach	150
Length of leg	140
Head width	140
Knee to toe	210
Butt to knee fold	260
Leg fold (knee) width	90

(d) Design and Prototype

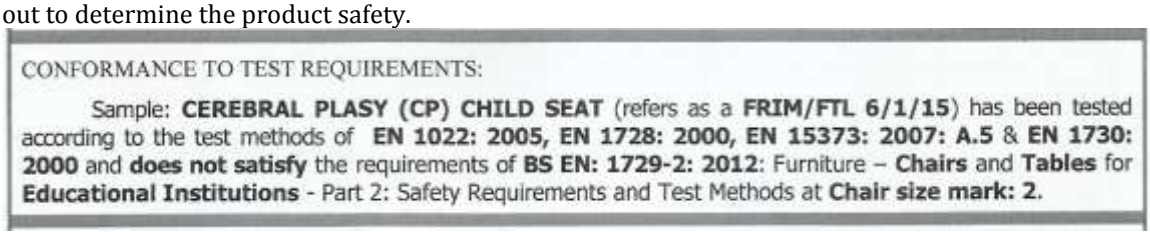
Criteria in designing the product are shown in Table 3.

Table 3: Design criteria for developing the CP Child Seat.

Design Criteria	Design 1	Design 2	Design 3	Design 4
Backrest	90 degree	45-180-45	45-180-45	45-180-45
Backrest inclination (tilted back)	No	Yes	Yes	Yes
Footrest	Yes	Yes	Yes	Yes
Adjustable footrest	Yes	Yes	Yes	Yes
Dismantled	Yes	Yes	Yes	Yes
Stopper	Yes	Yes	Yes	Yes
Adjustable stopper	No	Yes	Yes	Yes
Wheels	Yes	Yes	Yes	Yes
Table	Yes	No	No	Yes
Foam	Yes	Yes	Yes	Yes
Leather	Yes	Yes	Yes	Yes
Seat belt	Yes	Yes	Yes	Yes

(e) Product Evaluation

After selecting the suitable design for the seat, the prototype of CP child seat has been tested by Forest Research Institute of Malaysia (FRIM) Furniture Testing Laboratory at Kepong. The testing was carried out to determine the product safety.



CONFORMANCE TO TEST REQUIREMENTS:

Sample: **CEREBRAL PLASY (CP) CHILD SEAT** (refers as a **FRIM/FTL 6/1/15**) has been tested according to the test methods of **EN 1022: 2005, EN 1728: 2000, EN 15373: 2007: A.5** & **EN 1730: 2000** and **does not satisfy** the requirements of **BS EN: 1729-2: 2012**: Furniture – **Chairs** and **Tables** for **Educational Institutions** - Part 2: Safety Requirements and Test Methods at **Chair size mark: 2.**

RESULTS AND DISCUSSION

(a) Results

The comparisons of four prototypes have been made to determine the suitable design for developing the Cerebral Palsy Child seat. Table 4 shows the prototype of product design and Table 5 shows the comparison of product design characteristics. Figure 2 shows the prototype that has been tested at the testing laboratory, FRIM.

Table 4: Prototype of product design.

	
CP Child Seat for Design 1	CP Child Seat for Design 2
	
CP Child Seat for Design 3	CP Child Seat for Design 4

Table 5: Comparison of product design characteristics

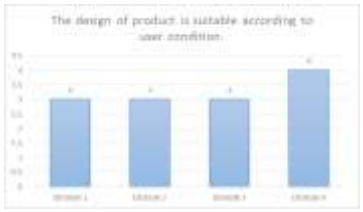
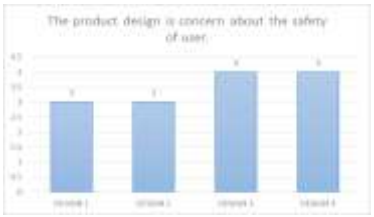
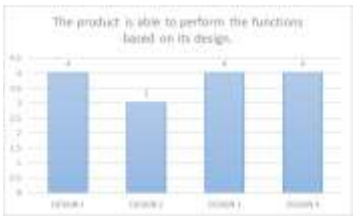
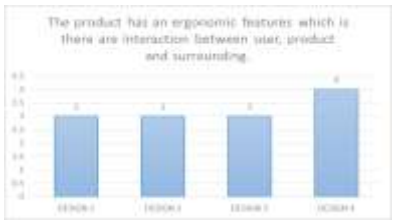
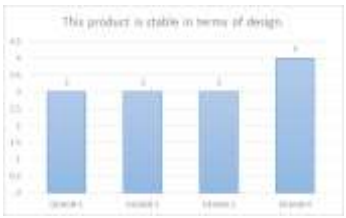
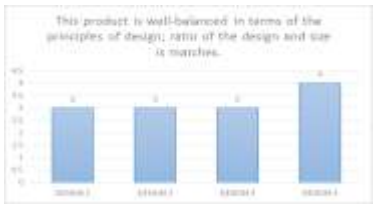
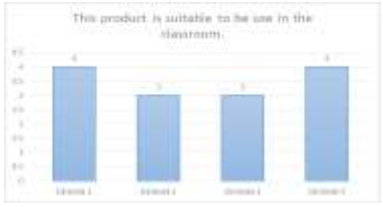
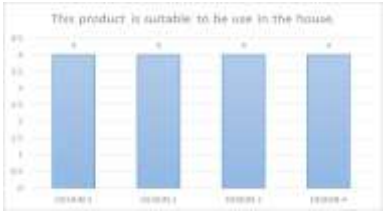
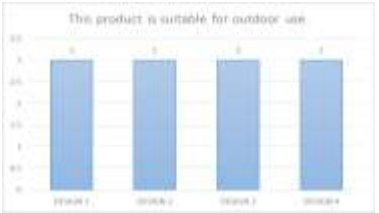
		
		
		

Figure 2: Prototype testing

(b) Discussion

(I) Analysis of questionnaire

From the analysis**,** design 4 is more preferable by the respondent based on the highest score shown:

i. The design of the product is suitable according to user condition.
ii. The product has an ergonomics features which is there are interaction between user, product and surrounding
iii. The product is stable in term of design
iv. The product is well-balanced in terms of design principle, design ratio and size is matches

(II) Furniture Testing Laboratory Test Report (Job No: FRIM/FTL 6/1/15)

Based on the product evaluation, it was found that:

i. Testing of Chairs: pass all the test required
ii. Testing of tables: fail for stability test (refer to Figure 3) and vertical static load test (refer to Figure 4)

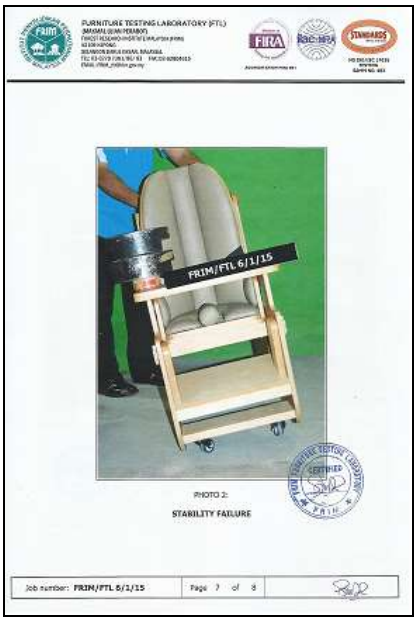


Figure 3: Stability failure

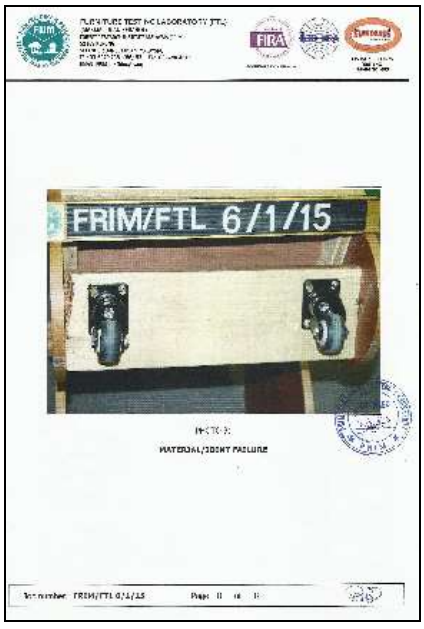


Figure 4: Vertical static load (material or joint failure)

CONCLUSION AND RECOMMENDATION

From this study, it can be concluded that Cerebral Palsy Child Seats have been successful developed based on doctor, therapist, clinician and parents' requirement. Product testing has been carried out to evaluate the product in terms of safety. Although design 4 is preferable by the respondent, the safety aspect should be improved. Recommendations by FRIM should be considered to enhanced the design and material used. The recommendations by FRIM are:

i. Straps used should be replaced by Velcro straps to fully support the children body.
ii. The inclination position should be improved. A special type of hardware can be used for the tilting mechanism.
iii. The wheels with 10cm diameter and rubber type are more preferable because it is suit for indoor and outdoor use.
iv. The wheel position should be redesign to overcome the stability failure.
v. The footrest joint and design should be enhanced so that the child will be more comfortable and to overcome the joint failure.
vi. All the sharpen edge should be radius of 2 mm.

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