

Design and development of an adaptive chair for children with motor disabilities

AMRITHA, R S

Kerala State Institute of Design (KSID), Kollam, Kerala, amrithars98@gmail.com

ALOK, KRISHNAN, T

Kerala State Institute of Design (KSID), Kollam, Kerala, alokthayyil@gmail.com

AKILA, SURENDRAN

Centre for Assistive Technology & Innovation (CATI), National Institute of Speech & Hearing (NISH),
Trivandrum, Kerala, akilas@nish.ac.in

An adaptive chair is a seating device that provides appropriate postural control and thus improves the functional capabilities of individuals with motor impairments. A study of the adaptive chairs available in the Indian market shows that there is much room for improvement in the ergonomic and aesthetic aspects of the product. This study is to collect the exact requirements of the users and design an adaptive chair that is suitable and affordable for the Indian context. Seating experts, caregivers as well as end-users were involved in the development of the chair and the improvement in posture and participation by the users are to be analyzed using evidence-based outcome measures.

Additional Keywords and Phrases: Assistive technology, Adaptive chair, Motor disability, User centric design

1 INTRODUCTION

Adaptive chairs improve the functional capabilities of children with motor disabilities and enable their participation in daily life activities [1-3]. A review of the adaptive chairs in the Indian market suggests that there are very few products in this segment and those are priced steeply. There is much scope for improvement in the ergonomic and aesthetic aspects of the product [4]. An exploratory survey conducted among parents of children with disabilities as well as rehabilitation professionals highlighted the need for a more comfortable and child-friendly adaptive seating system, that will be better accepted by the children.

In this project, experts and end-users were involved at every stage of design and development: from research and market study, ideation, trying different adjustments, form exploration to implementation of the current prototype. The redesign consists of aesthetic, ergonomic, and functional changes to the existing market alternatives, to provide a better experience for the user and the caretaker. The redesign was done using a combination of informal and formal user-centered design methods. More refinements are being done to the design to improve the comfort and usability of the adaptive chair.

2 METHODS

The methodology followed in this project are the qualitative method and field study. Parents, family members, doctors, physiotherapists, occupational therapists and speech therapists were interviewed. The researchers met around 10 families face-to-face and 1 family online. The interview questions for the parents included the history of their child's disability, stages of growth and improvements, therapy, daily routine of the child, use of assistive technology, attitude of family member's towards the disability and secondary user's interaction with the adaptive chair, etc. Interviews for the therapists are done by meeting them personally or over the phone. The main questions asked were related to further our understanding about cerebral palsy (CP), the intervention measures, seating requirements for a person with CP and so on.

Table 1. Details of case studies conducted during the field study

No	Age (years)	GMFCS (Gross Motor Function Classification System)	Insights	Component feature needed
1	5	5	Multiple disabilities, Cannot do anything by himself, has spastic CP, floppy head, poor hand-eye coordination	<ul style="list-style-type: none">● Ease of access for parents● The adaptive chair should be covered with soft form and safety edges for better comfort and safety● Head support.● Activity table

2	16	5	Needs support for all her activities, spastic CP, drooling, makes a sound to express her needs, hip dislocation and floppy head, loves to go outside, loves cartoons, facing a lot of difficulties with the current CP chair like, not the correct fit, as she lifts her leg it hits the activity table and hurts her leg, The unpredictable hand movements cause to hit on the side of the chair which is having sharp edges and is not cushioned	<ul style="list-style-type: none"> ● The material should be waterproof, ● Trunk support belt and hip support belt ● wheels for movement, adjustable seat length, detachable activity table, no metal protruding parts
3	5	4	Cannot sit by herself and can't speak she is also facing with stiff hands and a drooling mouth, malnutrition	<ul style="list-style-type: none"> ● Easy access for parent ● wheel with locking mechanism,
4	10	5	90% disabled, support needed for sitting, multiple disabilities. Outgrown the CP chair which is provided for him, loves to hear the sound which comes from hitting the chair with his hand.	<ul style="list-style-type: none"> ● Length-adjustable seating
5	10	5	Multiple disabilities, bedridden, needs support for all his activities, seizures twice a day	<ul style="list-style-type: none"> ● Adjustable seating positions, ● Soft and curved edges
6	16	2	Multiple disabilities, Walks with the support of assistive devices, helps in cooking.	<ul style="list-style-type: none"> ● Adjustable belts provided at knee and foot
7	2	4	Multiple disabilities, complete support needed, deaf and blind	<ul style="list-style-type: none"> ● Activity table with raised edge

3 RESULTS

From our research and case studies, we have found out that each CP child is different and hence their needs are also different.

- Most of the CP chair makers in India are not considering the aesthetic part and comfortability of the clients.

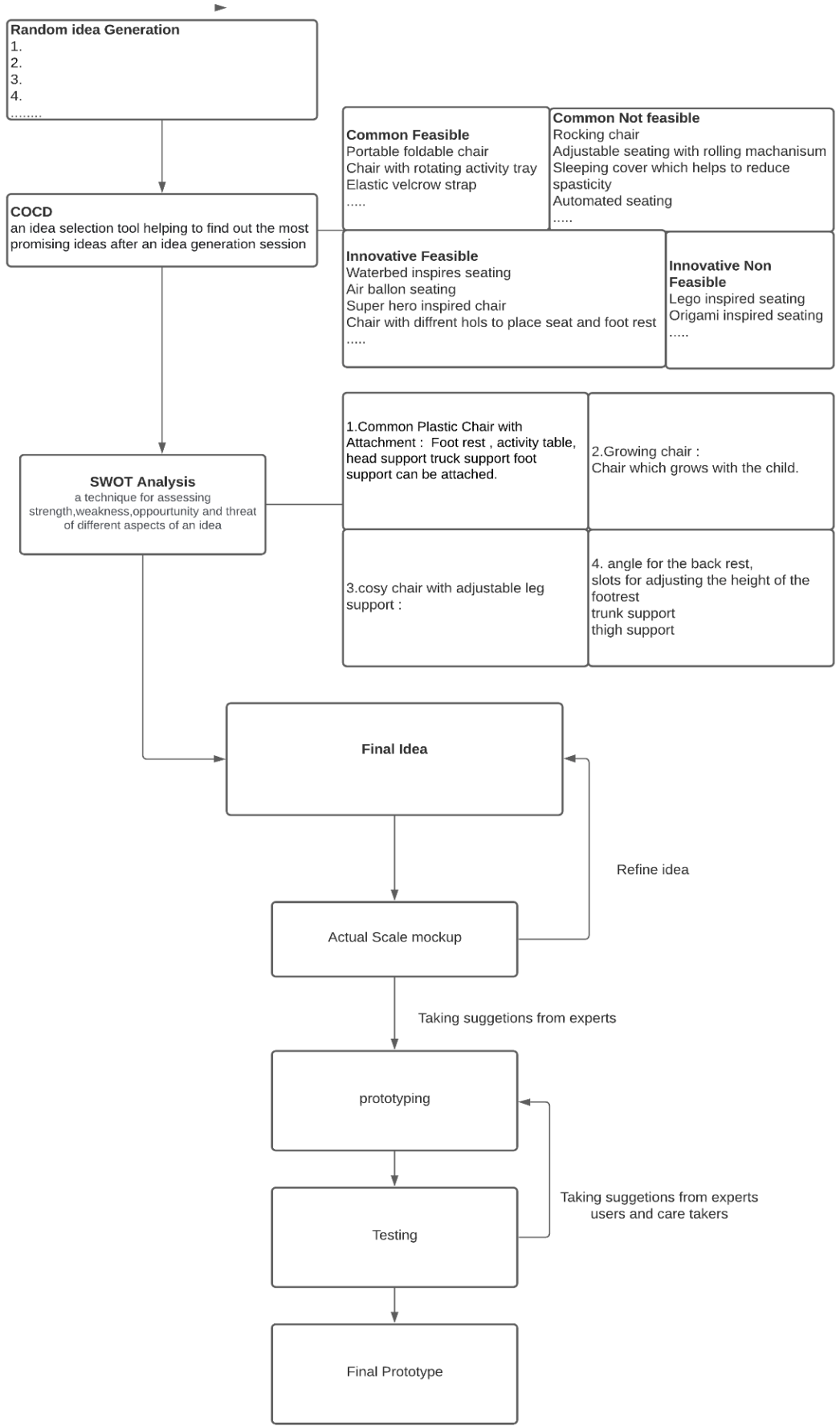
- The adjustability factors are not there in most of the chairs.
- The adjustable chairs are not accessible for a low-income family because of the cost.

The design brief is to create a seating system for children with motor disabilities that is customizable as per the requirements of the child and is cost-effective

Ideation

Based on the research and inputs, the ideation process was started. A diverse set of ideas were generated using a variety of techniques. The ideas are generated by Random ideas and customized idea generation. Used COCD method for idea selection

Design Process



3.1 Refined Idea:

The refined concept developed from existing concepts after some more research and inputs from experts. Different angles are included in the backrest and height adjustment for the footrest, neck support, wheels are attached for moving, leg separator and neck support.



Figure 1: Refined idea small scale mock-up

Feedbacks from experts on mock-ups

The seat can be given some tiltable adjustments so that they can do some exercises which improve the strength of the child's legs

- Need partial head support which can be detached
- Trunk support which helps the child during speech therapy
- It should be easier to change the posture of the child during an interval of 2 hrs.
- Needs a strap on the knees. The child should feel safe in the chair.
- For children with scissor-gate there should be a leg separator to keep the legs apart.
- In order to improve hand functioning, the child needs to place his/hers hands in the centre line of the body.

Suggested position of seating to strengthen the leg muscles

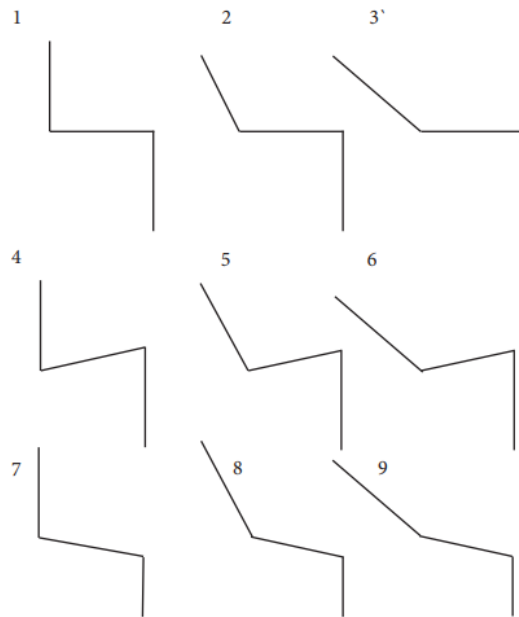


Figure 2: 1. 90 degree angle helps them to sit in a better position 2. 130 degree angle for backrest 3. 150 degree angles for back rest 4, 5, 6. Seat angle at 30 degree up-word for strengthening the hip muscles exercise 7, 8, and 9. Chair positioned in different back rest angle and seat at 30 degree down-word for strengthening the knees exercises.

Final concept

The concept is to provide better seating for the child with CP. In this concept, both the backrest and seat can be adjusted according to the child's comfort. And it is supported with. Headrest, trunk support, adjustable activity tray, adjustable footrest, removable leg separator, multiple angle adjustments for backrest and seat. Knee supporting belt, foot-supporting belt.

1:1 scaled Mock-up feedback from experts

* Angle of backrest - If you add one more angle to lie down it will be easier for patients and caretakers to feed the children

* Footrest - According to the disability some children may require a belt for the footrest

* Leg separator - Gradually width increasing leg separator

* Activity tray - Inside the shape of the activity tray must be a curve

Measurements for the prototype was taken according to the Indian anthropometric data of children within the age 5 to 10 years

Sitting Posture		5 Years	10 Years
Seated Eye Height	0.70H	696.5	903.7
Elbow Height	0.41H	407.9	529.3
Height of Seat	0.25H	248.7	322.7
Width of Seat	0.25H	248.7	322.75
Front of Knee to Buttock	0.34H	338.3	438.94
Height of Stool	0.37H	368.15	477.67
Width of stool	0.20H	199	258.2
Depth of Stool	0.16H	159.2	206.56
Height of Foot Rest	0.11H	109.45	142
Depth of Seat	0.24H	238.8	309.84
Floor to Top of Thigh	0.38H	378.1	490.5
Comfort Zone for Leg Movement	0.35H	348.25	451.8
Top of Backrest to Floor	0.44H	437.8	568.04
Seated Height	0.78H	776.1	1006.98

Table 2. Measurements used to make the final prototype

The attributes we have chosen to design the forms are caring, friendly, happy and safe.

We have chosen parrot green, sky blue as the primary colour palette to make the prototype. Green, blue promote calm and a feeling of well-being. Blue lowers body temperature. Green helps to relax the nervous system and lessens feelings of stress. It seems to help with communication and developing speech skills. Cool colours may be a good choice for individuals where reducing stimulation is a high priority, such as those with ADHD or the hypersensitive variation of autism.

TESTING

Observation1: The belt for the thigh is not fitting properly. Belt shouldn't irritate the child while sitting

Suggestions and comments from parents

1: Should reduce the weight of the prototype. Very helpful for the children.

Observation2: Proper hip support is needed. Child loves the reclined position, she felt very relaxed in that position than in the upright posture.

Suggestions and comments from parents

2: Should reduce the weight, Need a hip supporting belt

Observations 3: Using it daily two to three times for 20 mints a day. The parents use the adaptive chair mainly for his speech therapy. It is easy to sit and clean. If the trunk belt was better they prefer to keep him for a longer time.

Suggestions and comments from parents

3: The trunk belt is not supportive, it should be thicker. The prototype is heavy - not easy to move. The placement of the handle is not correct so it is difficult to push. They prefer a foldable wheelchair because it is portable, one time investment. If the trunk support was much better than they are ok with the chair. Better to feed him in his mother's lap. The angle in the adaptive chair prototype is not suiting for him.

Feedback for the prototype from experts

Could have looked at modular aspect of a product, which then could be catered to diverse users. Could have been better if there was analysis and some criteria for the location and shape of knobs and other mechanisms for adjusting the angle and height, such as the frequency of usage, by whom etc. Could have looked at the clean ability/serviceability of the product and its details.

Trial and error- different mechanisms tried

Activity tray: Thought about magnets and tower bolts to fix the activity tray, later we used Velcro. This makes it easy to detach from the chair and at the same time provides enough strength to withstand unwanted movements from kids.

Movements of the seating: Car seat sliding mechanism was tried initially but it was too heavy for a chair so we made a normal sliding tray using L angle.

Footrest fixing: First we thought of drilling holes in the side panel so that we can use a bolt to fix the footrest. Later we changed to a magnet because it will be unobtrusive and aesthetically pleasing. It is also functionally more appropriate.

Main components of the adaptive chair:

Adjustable seating with leg separator:

Sliding mechanism for seat is to adjust the length of the seat according to the users comfort, the angle of the seating area can also be adjusted so that the child can do hip strengthening exercise and knee strengthening exercises (suggested by experts).

Back rest:

The angle of the back rest can be adjusted according to the users need.

Neck support:

To support the floppy necks .This is made with cushioned pillow which is attached to the backrest using a Velcro. Washable material is chosen for neck support because the some users have excess drooling issues.

Trunk support:

A belt to support the trunk, it is designed for proper positioning of the user. These supports provide complete chest support and the right amount of shoulder movement for a perfect fit. They offer balanced sitting position maintaining midline position for the ones who are unable to sit in upright position

Side panels:

Are properly cushioned from inside for the safety of the child. The outer part is aesthetically designed considering the primary and secondary user.

An activity tray

An activity tray which is detachable with a Velcro support is height adjustable and tiltable. The activity tray is provided with edge guards to prevent falling of materials both sides of the activity table are properly cushioned in order to avoid accidents by hitting of legs or other parts.

Footrest:

Height adjustable foot rest with strap and thin layer of cushioning. This makes the chair grow along with the child and provide a wonderful experience in their life.

Wheels:

Wheeled mobility of the adaptive chair with braking system helps the children in the discovery of the world.

Bottle holder:

An add-on feature to keep the water bottle beside the child as this will help the parents whose kids have drooling problems.

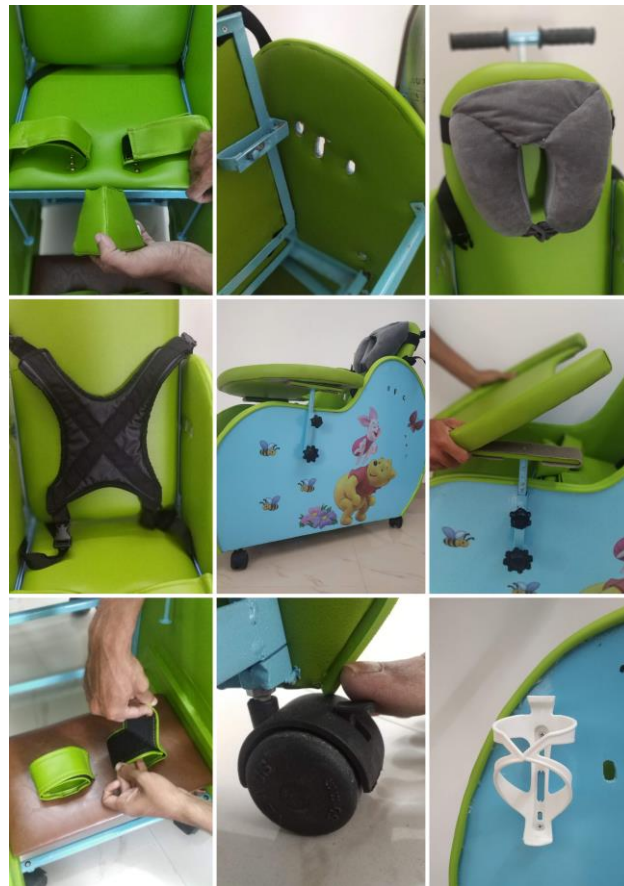


Figure 3: Different compounds of the final prototype

Our exploratory interviews and studies indicated that every child with cerebral palsy has unique seating and positioning needs. The following are the important features that we have included in the adaptive chair prototype: (1) Adjustable seating with leg separator, neck support and trunk support, (2) Seat and side panels are covered with foam, which makes the user comfortable and easy to clean and maintain, (3) An activity tray which can be attached at the desired height and a bottle-holder, (4) Wheeled mobility of the adaptive chair with braking system helps the children in the discovery of the world. Handles are provided for caretakers to manoeuvre the chair, (5) Pleasing colours and child-friendly graphics on the side panel makes the product more acceptable for the children.

The latest prototype is currently being tested with the end-users and measures such as the Canadian Occupational Performance Measure (COPM)[5] and Family Impact of Assistive Technology Scale for Adaptive Seating (FIATS-AS)[6] will be used to evaluate the improvement in the performance of the end-user, upon using the chair. The COPM is an individualized measure designed for use by occupational therapists to detect the change in a client's self-perception of occupational performance over time. The FIATS-AS was designed to detect the parent-perceived effects of adaptive seating interventions on the lives of children with physical disabilities and their families.

4 CONCLUSION

Most of the commonly available adaptive chairs in India do not consider the different ergonomic factors, especially in terms of comfort, both physical well as cognitive. The study tries to identify the ergonomic aspects that are important for the child and the insights generated have been used to come up with a broader list of ergonomic considerations for designing better adaptive chairs for children. It is important to look at an adaptive chair not just as an engineering product but more as a human product. It is not enough to simply address the problem at the minimum physical constraint level but to see it as an experience.

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