Jurnal Kejuruteraan SI 6(2) 2023: 73 – 84
https://doi.org/10.17576/jkukm-2023-si6(2)-08

A New Modification of 3 in 1 Standing Frame for Children with Cerebral Palsy

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Received 15 April 2023, Received in revised form 4 August 2023
Accepted 30 September 2023, Available online 30 December 2023

ABSTRACT

Standing Frame (SF) is commonly used in rehab training for children with cerebral palsy (CP), but the design regarding patients' needs, conditions, and environments is rarely investigated. In this study, the researchers modified the standing frame by adding a controlling and monitoring system and included a 3 in 1 design that consisted of lying down, sitting, and standing postures. Six (6) volunteer respondents answered the questionnaire, and three (3) participants with CP were involved in this research to determine the usability of the modified 3 in 1 SF. The result of the questionnaire found that the 3 in 1 SF developed were interesting products, easy to use, safe, creative, and innovative products. Furniture Testing Laboratory results are: there are no fractures of any member, joint, or component, there is no loosening of joints intended to be rigid, seating fulfills its functions after removal of the best loads, and seating fulfills the stability requirement. Overall, 3 in 1 SF is well-developed, but a little bit of improvement is still needed for further research. Hopefully, the 3 in 1 SF will help the children with CP develop self-reliance and assist them in their everyday activities at home and school.

Keywords: Cerebral palsy; assistive technology devices; standing frame; design; rehab

INTRODUCTION

Global Burden of Disease (GBD)-WHO (2022) reported that about 1.3 billion people experience significant disability. This represents 16% of the world's population or one in six of us. Globally, 8.1 million (7.1-9.2) or 1.2% of children under five years are estimated to have CP.

Assistive products such as standing frames, wheelchairs, and corner chairs can make a difference to all these people by helping to maintain or improve their functioning and independence, thereby promoting their well-being. Globally, more than one billion people need one or more assistive products, and it is estimated that by 2030, more than two billion people will need at least one assistive product, and many older people will need two or more. Only one out of every ten people in need of assistive products has access to them (WHO, 2018). Children with CP have one of the highest rates of long-term impairment. According to European data,

the average frequency of CP is 2.08 per 1000 live births, but in the group of children born with a body weight below 1500 grams, the frequency is 70 times higher when compared with the group of children with a body weight over 2500 grams at birth (Sadowska, Sarecka-Hujar and Kopyta 2020). The Malaysian Health Ministry reported there were 2,766 children with special needs in 2012, of whom 215 had CP. The Social Welfare Department reported that there were 5,840 children with CP in Malaysia between 2011 and 2017.

This study is based on the researchers' own experience in developing assistive technology devices (ATDs) and being involved in the cerebral palsy environment since 2012. Working with medical doctors, therapists, parents of children with CP, rehab tool designers, and rehab tool manufacturers makes researchers realize how to develop a good design of ATDs for children with CP. A child with CP cannot stand up by themselves. They need an assistive device to help them. Supporting aids or ATDs equipment will basically meet the CP children's needs for self-reliance and assist them in their everyday activities at home and school. They also need aid equipment to assist them in getting the basics of exercise, which are lying, sitting, and standing. This is crucial in supporting them in becoming more independent. It is also common for parents to have problems finding suitable equipment for their children.

Based on the needs analysis phase, the doctors (n=2) and therapists (n=2) stated that additional equipment to assist a children with CP in their everyday lives should be built with the patient's needs, condition, and environment in mind. Most things readily available in the Malaysian market are large and bulky (matching to European sizes), as well as pricey because they are imported.

In addition, existing aids on the market only have one function, as mentioned by the doctor and therapist. This means that the majority of CP-supportive equipment on the market only allows for one exercise at a time. Nevertheless, gait trainers for adults safely support users in an upright position, allowing them to practice walking independently with the help of a physical therapist. The purpose is to strengthen muscles and joints, enhance posture, endurance, balance, and retrain the legs for muscle memory (United Cerebral Palsy 2018)

Gait trainers for adults safely support users in an upright position, allowing them to practice walking independently with the help of a physical therapist.

Since good positioning is a big component of gait training, this study is carried out to develop a 3 in 1 Standing Frame (SF) for CP children that will help them exercise in lying, sitting, and standing positions at the same time. The researchers predicted that this 3 in 1 SF might enable greater adjustability to meet the demands of the patient, particularly in enhancing upright posture, condition, and environment, as compared to the standard standing frame now on the market. The 3 in 1 SF in this trial, however, is exclusively for children with CP who have head control, Gross Motor Function Classification System (GMFCS) levels IV to V, and mild symptoms.

METHODOLOGY

Figure 1 depicts the four steps included in this study.

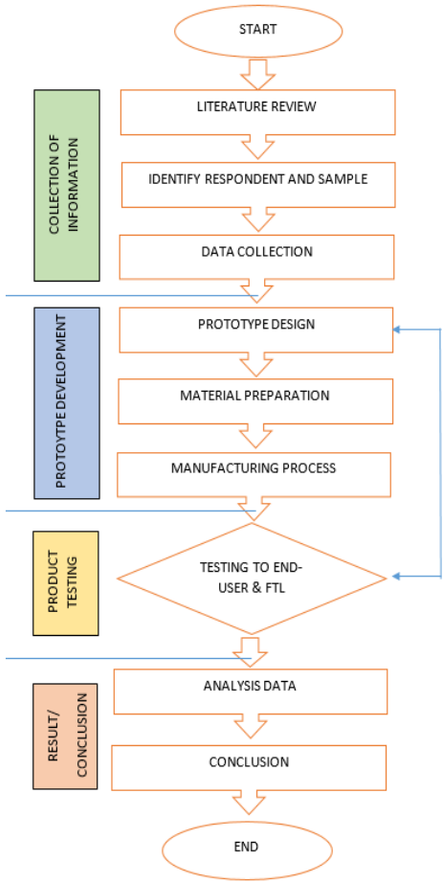

FIGURE 1. Research flow

PHASE 1: COLLECTION OF INFORMATION

In phase 1, the needs analysis, literature review was conducted to find out on cerebral palsy symptoms, types of assistive technology devices available in the market, and SF design from literature. Besides that, field visits were conducted at two OT clinics at government hospitals and one private rehab center located in the Klang Valley to find out the needs of the SF design based on three patients (see Figure 2).

FIGURE 2. Visiting physiotherapy center, Hospital Canselor Tunku Muhriz, UKM

The physiotherapists' suggested sample criteria are as follows: (i) Children with minor CP symptoms who can control their heads; (ii) Gross Motor Function Classification System (GMFCS) levels IV to V, indicating that the child has stronger below-the-waist strength; and (iii) a slight ability to stand.

SAMPLE

In this case study, an eight (8) year old child with CP has been selected. The child has mild symptoms associated with quadriplegia CP. The parents have granted permission to use their child as a research sample in this study.

The physical body measurements of the sample were gathered with the help of one of the five occupational therapists who was also a teacher at the rehab center. The body measurement is required to identify the product size to be developed. The anthropometric data collected were based on the MS ISO 7250 (2003) standard (Malaysian Standard, 2003). The standard measurement that was taken is shown in Table 1 and Figure 3 depicts how body measurements are taken.

TABLE 1. Anthropometric data of the sample using MS ISO 7250 Standard

PATH	MEASUREMENT (mm)
1	1220
2	680
3	390
4	370
5	310
6	190
7	320 (right) , 350(left)
8	380 (right), 400 (left)
9	130
10	540
11	310
12	300+/- 320 (right), 330+/-350 (left)
13	310 (right), 330(left)

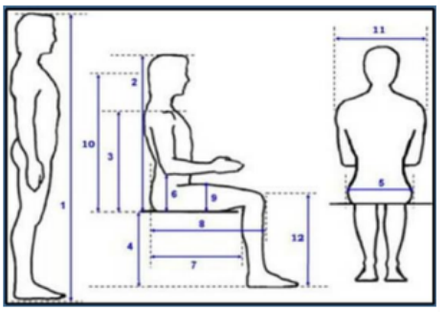

Figure 3.4: Anthropometric measurement MS ISO 7250 Standard (Malaysian Standard, 2003).

FIGURE 3. Taking body measurement

PHASE 2: PROTOTYPE DEVELOPMENT

The existing standing aids or standing frame in the market need to be improved in aspects of mobility, dismantling, unsuitable product size, and manpower required to hold the child in a standing position.

1. Design idea: the 3 in 1 SF is an adaptation design from CP chair and standing aid.

FIGURE 4: Design Idea

2. Design process: the design idea is transferred into AutoCAD drawing as shown in Figure 5 to Figure 7.

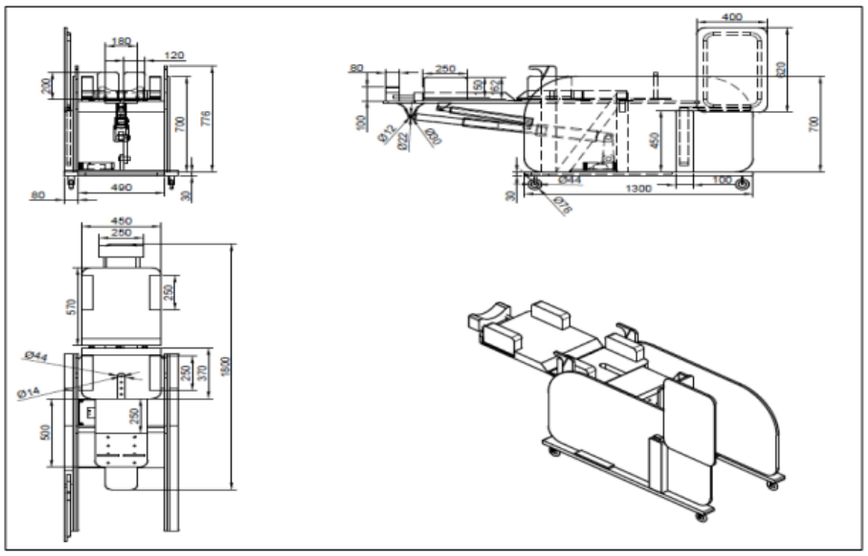

FIGURE 5. The 3 in 1 SF in a lying position

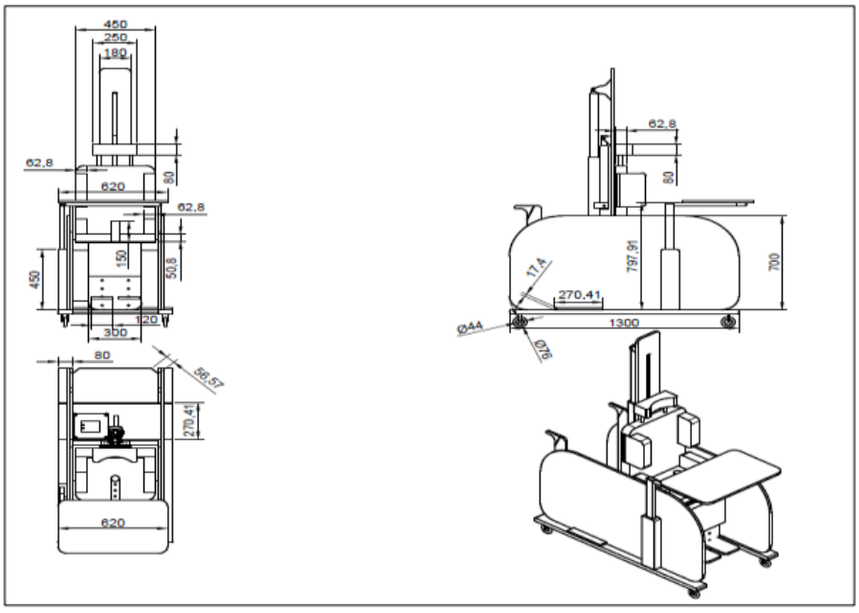

FIGURE 6. The 3 in 1 SF in a sitting position

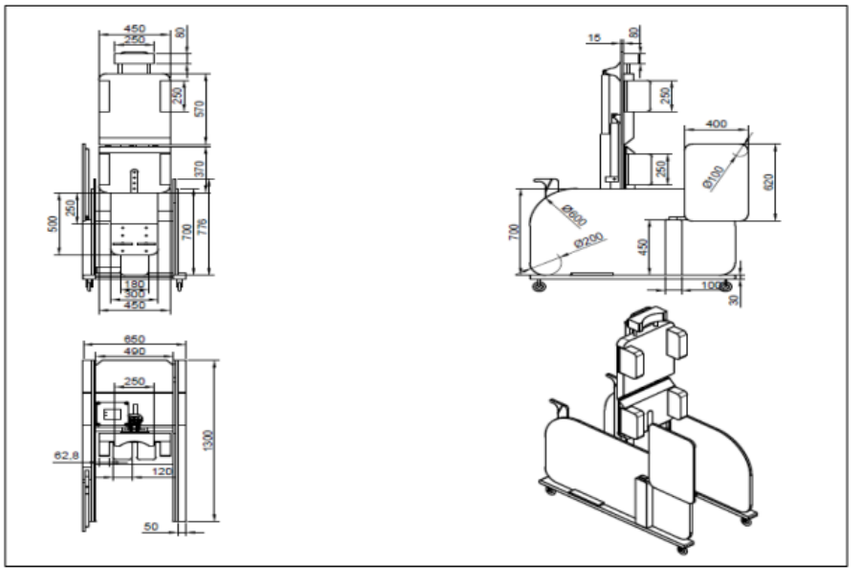

FIGURE 7. The 3 in 1 SF in a standing position

MANUFACTURING PROCESS

The manufacturing process of 3 in 1 SF is shown in Figure 8.

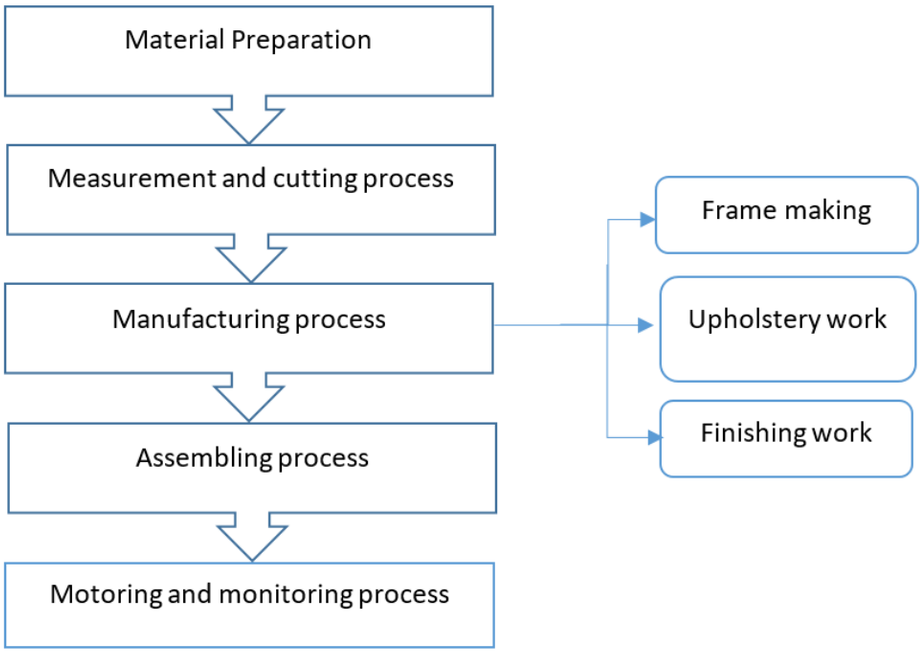

FIGURE 8. Manufacturing process

1. Material preparation: rubberwood is the main material used for making the frame.
2. Measurement and cutting process: material is cut according to the cutting list and route sheet.
3. Manufacturing process: is divided into 3 main process which is frame making, upholstery work, and finishing work.
4. Assembling process: all parts are assembled together.
5. Motoring and monitoring process: the system for motoring and monitoring is designed and attached to the 3 in 1 SF. For the monitoring system, the device was connected to Blynk Application by mobile monitoring. Blynk platform powers low-batch manufacturers of smart home products, and complex HVAC systems. Blynk was designed for the Internet of Things

Two units of 3 in 1 SF have been developed for user testing and furniture testing laboratory (physical testing) as shown in Figure 9.

FIGURE 9. Prototype of 3 In 1 SF to be tested by the end-user

FIGURE 10. Prototype of 3 In 1 SF to be tested in Furniture Testing Lab (FTL)

The development of 3 in 1 SF will essentially assist the CP child in learning to stand and strengthen their leg muscles. This enables the patient to determine and correct their optimal posture in order to prevent and reduce muscle stiffness. Treatment can help children deal with symptoms, avoid issues, and improve their abilities. One of the most significant treatments is physical therapy.

PHASE 3: PRODUCT TESTING

Domestic tests were conducted at the Furniture Testing Lab (FTL) based on the following standard tests:

1. BSEN 12520:2015 - Strength, durability, and safety in furniture. Domestic seating requirements
2. BSEN 1022:2005 - Seating for furniture. Stability determination
3. BSEN 1728:2012 - Methods for determining the strength and durability of furniture seats.

The user testing, as shown in Figure 11, was performed to ensure the prototype's functionality and the product's safety for the end user. The testing was conducted under the supervision of an occupational therapy doctor from Hospital University Technology Mara (UiTM) and with the assistance of an occupational therapist.

Six (6) volunteer respondents completed the questionnaire, and three (3) persons with CP participated in this study to assess the usefulness of the modified 3 in 1 SF. Six respondents completed a questionnaire, which was evaluated using Microsoft Excel. Phase 4 discusses the findings.

FIGURE 11. Product testing to end-user

PHASE 4: RESULTS AND DISCUSSION

During the product testing phase in Phase 3, the FTL concluded: (a) there are no fractures of any member, joint, or component, (b) there is no loosening of joints intended to be rigid, (c) seating functions after the best loads are removed, and (d) seating meets the stability requirement. The FTL is performed to confirm the product's safety before it is tested on the end user.

The assessment of the device for end user testing was based on a questionnaire presented to a medical doctor, occupational therapist, and parent of a kid with CP. Figures 12 through 15 illustrate the outcomes.

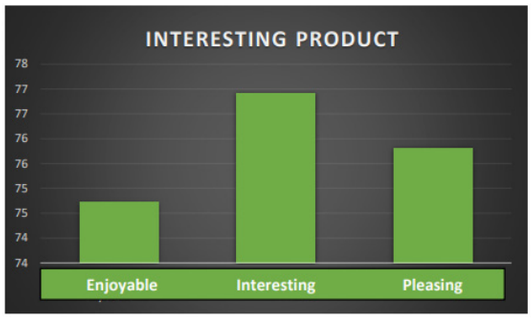

FIGURE 12. Interesting product data

FIGURE 13. Easy to use data

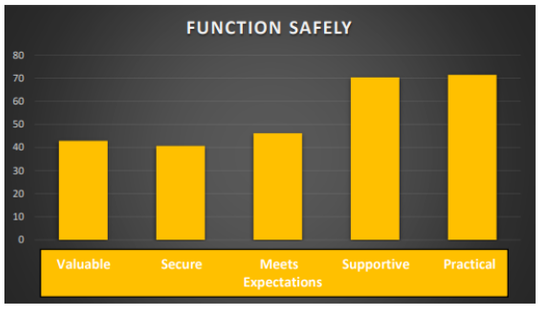

FIGURE 14. Function Safely data

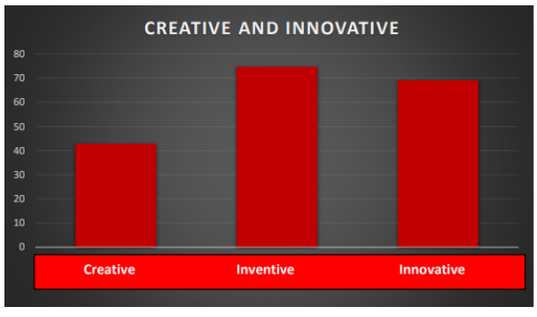

FIGURE 15. Creative and innovative data

In addition to the analysis of the questionnaire, there are some suggestions from the respondents who answered the questionnaire as follows:

1. Overall the product developed is very good and needed in the market.
2. This product is great for improving the health and independence of children with cerebral palsy.
3. It can also prevent parents from getting back pain or other musculoskeletal diseases when handling children with cerebral palsy.
4. The product still needs further improvement. Please emphasize safety aspects such as increasing the firmness of the 'backrest' so that it does not sway and a safer roller hydraulic system.
5. The battery must be more durable.
6. The distance of the hand rest /activity board must be suitable so that children can use the hand rest or activity board for various functional activities and also to support their hands.
7. The product developed must also be according to the child's dimensions.

CONCLUSION

This paper has made a significant contribution to the field of study by developing a multi-functional standing frame that may assist CP children in getting more exercise in sitting, lying down, and standing posture by using only one product at a time. This discovery will assist CP children increase their independence, particularly their upright position and capacity to sit, stand, and lie on their own. Despite the fact that the study is confined to children with CP due to the GMFCS level, it will be valuable for rehabilitation designers and parents looking for appropriate assistive technology devices for their children. Future research could concentrate on standing frame design principles to match the demands, conditions, and environment of patients.

ACKNOWLEDGEMENT

The researchers would like to express their gratitude to the Ministry of Higher Education and the Department of Polytechnic and Community College Education for providing financial support through the TVET Applied Research Grant Scheme (TARGS: 1002/20). This paper was also partially supported financially by Kolej Komuniti Kuala Langat, Department of Polytechnic and Community College Education. Special thanks to the Commercialization, Research and Innovation Unit, Polytechnic Sultan Salahuddin Abdul Aziz Shah, and Malaysian Advocates for Cerebral Palsy (MyCP) for their support and vital information throughout the project's implementation. We are also grateful to our collaborators, Jabatan Perkhidmatan Pemulihan Perubatan, Hospital Canselor Tuanku Muhriz (HCTM), Fitec, and Genius World Solution Center. It is our pleasure to thank all of the volunteers that participated in this research.

ADDITIONAL INFORMATION

This 3 in 1 SF was submitted to MyIPO and patented filing with registration number P12021007795 on 27 December 2021.

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