



Re-evaluation of the Cerebral Palsy's orthotic need in Adaptive Seating Orthosis (ASO) design

ABSTRACT

Adaptive seating orthosis (ASO) for Cerebral Palsy (CP) patients in Malaysia mostly are imported, highly expensive for the bottom millions, bulky and complicated design structure, and not accommodating users' preferences. Through a study involving 10 CP patients with their parents/guardians in Malaysia, the goal of this paper is to re-assess the design needs of CP's orthotic in ASO design. The purpose of the study is to identify the difficulties, as well as the ergonomic and functional problems, in caring for CP patients with the current ASO. The result of the study revealed several of the problems that parents/guardians face while taking care of the CP patient, mainly caused by technical flaws in the current ASO design. Therefore, a few design criteria have been proposed to solve the addressed problems. The contribution of this study will help as a preference for the improvement and development of ASO design.

KEY WORDS

Cerebral Palsy, Adaptive Seating Orthosis, design thinking, ergonomics, product design

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Introduction

One of the Six Strategies Trusts outlined in the Eleventh Malaysia Plan (RMK-11) is to enhance the well-being of Malaysian people by providing better healthcare, particularly in the B40 group. The treatment for CP in Malaysia; a long-term condition that developed when areas of the brain that control muscles are damaged is one of the main health and well-being problems. Postural control deficiencies as a major component of gait disturbances in CP patients have been proposed by medical experts. The lack of suitable seating modifications has made it difficult to reach an independent sitting and has had an impact on their quality of life. Due to the condition, various Adaptive Seating Orthotics (ASO) products have been purposely developed and produced for CP patients. However, the majority of ASOs for CP patients in Malaysia are imported, very costly for the bottom million, heavy with bulky and complicated design structure that does not fit Malaysian anthropometric details, daily used and

preferences (Hui et al., 2011; Kamaralzaman et al., 2018; Tan & Yadav, 2008; Tharshini et al., 2016). As a response, it is essential to have a good ASO design that can easily accommodate day-to-day activities, purposely created based on Malaysian anthropometrics, and affordable. Matos et al. (2014) claim that the last decade has seen an increased emphasis on the design of medical equipment for the disabled, especially on patient safety, and a few projects have been set up to strengthen these elements. In any event, Matos et al. (2014) also claimed that most multidisciplinary organisations responsible for the advancement of products for disabled have struggled to recognise and integrate good design as a fundamental feature. In addition, the perception was compounded by the belief that the vast majority of items designed for disabled do not adequately address the actual and realistic needs of users. For instance, issues such as symbolic functions, aesthetic or, in outrageous cases, ergonomic and functionality are not generally considered significant as mechanical performance or economic

and innovative variables. Therefore, it is important that the product development of ASO for CP patients should include the reflection of designers in considering influential variables such as users' actual needs, accessibility, ergonomic elements, and aesthetics. Thus, our research aims to re-evaluate the ergonomic issues, needs, functional and practical problem for the development of CP's ASO design in Malaysia, based on the aforementioned claims. The research model of the study was based on the framework of Ergonomics Ergo-system. Following that, based on the data analysis, a few design criteria will be outlined in order to determine the most suitable and appropriate design preferences for the improvement and development of ASO design.

Cerebral Palsy (CP)

According to Colver, Fairhurst & Phaorah (2014), CP was defined by the International Executive Committee for the Definition of CP as a category of persistent mobility and posture growth disorder, triggering cognitive activity limitations caused by non-progressive diseases that have emerged in the developing fetus or infant brain. In other words, CP is a neurological disorder that is caused by a non-progressive brain injury, malformation, or damage to the brain that happens during the growth of the child's brain (before birth, during or shortly after birth). Meanwhile, according to Hughes et al. (2012), CP was described as a collection of persistent disorders of movement and posture development that cause activity restriction and are attributable to non-progressive problems in the developing fetus or new-born brain.

According to Tharshini et al. (2016), most of the babies born with CP problems are prone to complications such as; (1) motor movement problems, (2) stiff or loose muscle problems, (3) weak muscle problems and (4) body balances problems. Sahinoglu, Coskun & Bek (2017) suggest that the typical musculoskeletal problems seen among CP patients are decreased flexor of the hip and knee. The thoracic-lumbar vertebrae are flexed to counteract the posterior inclination of the pelvis. Back-shifting balance compensation triggers thoracic kyphosis. However, in the thoracolumbar region, there is more flexion that complicates the regulation of the head, and the patient attempts to keep the head in place by slanting it forward or backward, which creates swallowing and speech difficulties. The deterioration of motor behaviour is closely related to a loss of postural control, creating a never-ending cycle and deteriorating the patient's static and dynamic stabilisation. Posture coordination defects have been indicated by medical professionals as a major component of gait disorders in CP patients due to a musculoskeletal problem, as a result, they find it difficult to remain motionless and spend the majority of their time sitting.

Adaptive Seating Orthosis (ASO)

Physical and occupational therapists regularly recommended ASO for CP patients since the 1960s to enhance their function and strengthen their developmental capacities. According to Bolas & Boyle (2017) through overcoming participation barriers in daily life activities such as play, ASO improves the occupational performance of CP patients. In specific, ASO is widely prescribed to strengthen posture in persons with disabilities, while improving volitional upper limb control. This is in line with previous studies by various researchers who have been actively searching for the most suitable choice of ASO for CP patients (Angsupaisal et al., 2017; Chung et al., 2008; Polhan et al., 2019; Ries, Novacheck & Schwartz, 2014; Ryan, 2016; Sahinoglu, Coskun & Bek, 2017; Vekerd, 2007). The seating orthosis developed by Polhan et al. (2019) and Sahinoglu et al. (2017) are shown in Figure 1 and Figure 2.



» **Figure 1:** Definitive custom seating orthosis wheelchair, adapted from Polhan et al. (2019)



» **Figure 2:** Adjustable seating orthosis, adapted from Sahinoglu, Coskun & Bek (2017)

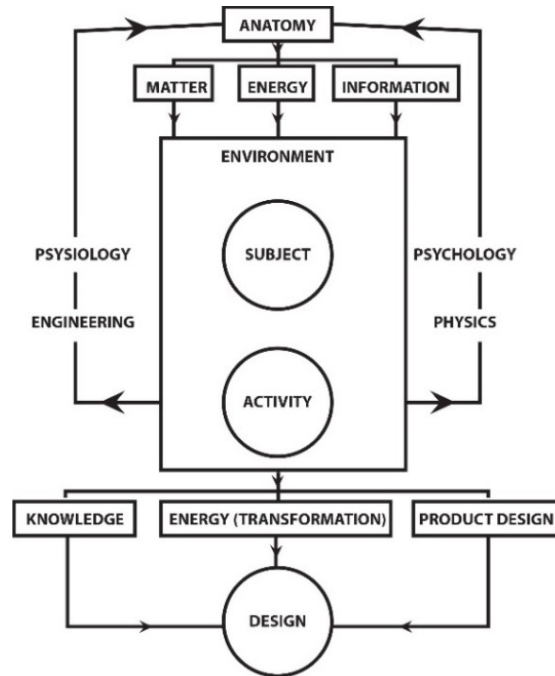
Based on an interview with parents regarding the seating and engagement of CP patients, Bolas and Boyle (2017) found that using the autonomous mobility and level of social skills of ASO patients is considered meaningful if they can be sociable, learn new skills, be self-sufficient, have fun, and achieve personal objectives. Therefore, Bolas and Boyle indicated that when evaluating the best for CP patients and their families, it is important to figure out what is relevant and important outcomes.

Based on the study conducted by Rigby, Ryan & Campbell (2009), the majority of parents reported favourable outcomes from using the ASO, such as their kid sitting better, did more, and was more active during the intervention phase by using the ASO for longer periods. Several parents reported improving the abilities of their child, while others claimed that their children were happier and more eager to sit and perform activities, and that they were now able to engage in face-to-face social contacts, leading to more socialising with family and friends. After the devices were withdrawn at the conclusion of the intervention procedure, some parents reported that their children were more passive and less engaged, while others reported that their children were less sociable and engaging. Nevertheless, parents considered the seating devices comfortable and easy to use during the intervention process, and many indicated that their child needed less assistance from the caregiver. Almost a quarter of parents mentioned how their child could join the family for meals, sports and social interactions now. Parents also reflected favourably on the portability of the ASO, stating that they used it while paying visits to relatives and acquaintances at their homes, they took the ASO with them, and they used it effectively in restaurants. A few families confirmed, however that the ASO did not fulfil the needs of every family. The most popular concerns were that the ASO does not give enough assistance, or the essential stability required by their child. These parents indicated that by using the ASO, they watched their child more closely. Several parents said that their child was bothered by the activity seat's straps and preferred to be confined rather than limited.

The Ergonomics Ergo-System Framework

Bridger's (2008) ergonomics ergo-system framework was used to develop the design needs assessment model. In this research, the framework is developed as a design paradigm to help designers' design thought throughout the stages as follows: (1) analysing the case empathically; (2) brainstorming and developing an idea for the user's requirements (based on the results of the analysis stage); (3) conceptualize and modelling process; (4) and reviewing the design prototype on a regular basis (see Figure 3). Generally, the framework serves as a blueprint for optimising system operation, but it can also be used in product design. The following five groups of theoretical elements of ergonomics speed up the process: (1) Psychology; (2) Engineering; (3) Anatomy; (4) Physics; and (5) Physiology. The system's foundation includes the subject's synchronisation in a specific setting. In order to make sense of the interaction, the subject's state or condition (matter) in a given environment or space must be understood. In theory, the state or situation will illuminate information on the subject's reflection on the physics of the world being experienced, as well as how it affects the subject's psychology and the need

for it. The articulation of anatomy and physiological requirements, on the other hand, would provide much needed design information for further refinement. The design assessment model is used in this study to determine the design needs of CP patients and their parents/guardians for product design development.



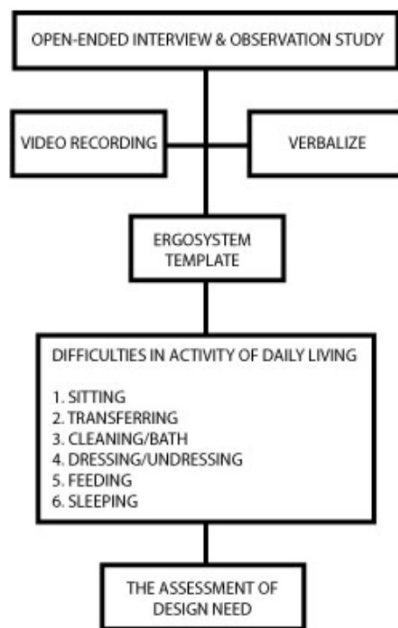
» **Figure 3:** Ergonomic Ergo-system Framework, adapted from Bridger (2008)

The framework of design needs assessment

As illustrated in Figure 4, the framework of design needs assessment (Sani et al., 2019; Kamil, Shi & Sani, 2020) was developed by incorporating ergonomic contexts, as described in Bridger's (2008) ergonomics ergo-system framework. The framework, in general, serves as a qualitative research blueprint for the procedures and strategy to assessing design needs. The framework's basis comprises an assessment of the subject's situation through an open-ended interview and observation study in a specific environment, such as the activity of daily living. The theoretical aspects incorporated from Bridger's (2008) ergonomics ergo-system framework will be utilised as a reference throughout the procedure. Video and verbalised explanations were gathered as empirical data, which was then analysed to determine the design needs.

Methodology

Based on Cross's (2001) proposal on the forms of design research, the nature of this study will be the 'research for design'; aims to create an artefacts, design methods, and



» **Figure 4:** *The Framework of Design Needs Assessment, adapted from Sani et al. (2019); Kamil, Shi & Sani (2020)*

forms of modelling. In this research, the objectives as follow: 1) to determine the technical difficulties faced by the guardians in taking care of the CP patient; and (2) to analyse the ergonomic issues due to the technical aspect in the existing ASO support. These research objectives were derived based on the context of the study; the context that helps to exemplify the primary subject, limits, and perimeter of information to be investigated, which is hoped to establish the design preferences for the development of ASO for Malaysian CP patients. Based on the incorporated ergonomic contexts by Sani et al. (2019) and Kamil, Shi & Sani (2020) the framework of design needs assessment divides the procedures and illustrates the strategy in accomplishing the research objective. In this study, the assessment of the CP's orthotic need for the development of ASO design was identified based on the investigation of problems faced by the guardians and CP patients such as the ergonomics and functional issues in using the existing ASO. The study was focused on the six activities of daily living, as follow: (1) sitting; (2) dressing/undressing; (3) transferring; (4) cleaning/giving bath; (5) feeding; and (6) sleeping. Nevertheless, this study also investigates the burden of cost and maintenance in using the existing ASO. Open-ended interview and observation study were conducted with 10 parents/guardian of the Malaysian CP patients. The study was conducted at Hospital Universiti Sains Malaysia in Kelantan during the first year of the research activity. The interview and observation were recorded using Zoom Q2 HD Video Recorder, and the video was processed using AVS Video Editor Software. The theoretical framework of the observation will be focus on behaviour analysis of the Malaysian CP patients (Austin & Delaney, 1998;

Zainal Abidin, Christoforidou & Liem, 2009; Kamil, Zainal Abidin & Hassan, 2018; Kamil, Zainal Abidin & Hassan, 2019b; Kamil, Shi & Sani, 2020; Kamil & Sani, 2021; Kamil, Hua & Sani, 2022). To extract the clear explanation and build the abstract thinking of the parent or the guardian, the analysis of interview in recorded video was systematically coded into information categories (Glaser & Strauss, 2017; Kamil, Zainal Abidin & Hassan, 2019a).

The analysis of the interview in recorded video was part of the process to gain an empathetic understanding and inform a clear design need. Using three phases of coding: (1) open coding; (2) axial coding; and (3) selective coding, the written verbal transcriptions from the interview data were analysed and methodically classified into information categories (Creswell, 2009; Saldaña, 2009). For example, in a study of issues in sitting activity (see Table 1), the researcher categorised the parents/guardian's utterance's selected emphases and obtained the utterance's attributes. Open coding starts with the generation of simple descriptive labels or speech analysis features in this work. In the 'Open Codes' column, an extract of open code from one of those utterance analyses may be seen. Axial codes, which are more abstract conceptual categories, are created from the open codes. Selective coding, in particular, required sorting and relabelling comparable coded data into conceptual groupings that were reduced from open codes. During the cycle, the code is fine-tuned to get the best match, and more than one axial code may be generated. In addition, data that was "divided" or "fractured" during the open coding process will be carefully reconstructed. At this level, the axis is a category developed from open coding. One of the aims of early coding is to identify these dimensions and organise the available codes along them.

The open codes in Table 1 have, for example, been renamed and reorganised in relation to one another. The researcher may need to go back to the data and recode the data in relation to the emergent concept summarised in the category or dimension after selecting a category or dimension.

According to Muller & Kogan (2012), Choosing which codes (from the axial codes) to further develop necessitated a selection on which themes to investigate. By analysing the interrelationships that occur among the categories generated in axial coding, the information was retrieved using selective coding (Creswell, 2009).

The chosen coding retains only relevant and applicable variables to the core variables along the procedure in order to generate explicit information. The core category (axial coding) was provided as a declaration of information, which was then categorise and recoded as selective codes. This approach may need to be performed a few times to establish the relationship between codes and arrive at the most credible explanation.

Table 1

Sample of Coding (Open Codes): Issues in Sitting Activity

Index	Respondent 1	Respondent 2
Protocol Time	10:30	14:20
Transcriptions	<i>"His neck will suffer the longer he sits. The neck cushioning is insufficiently comfy."</i>	<i>"Every time he sits, his neck appears to be out of position, resulting in frequent coughing and suffocation."</i>
Attributes	<p>1. The patient is unable to sit for an extended period of time.</p> <p>2. The neck cushion is inconvenient to use.</p>	<p>1. The form of the neck cushion did not support the proper neck posture.</p> <p>2. Coughing and suffocation are caused by poor neck position.</p>
Open Codes: Categories of information	The patient is unable of sitting for long periods of time. Due to an uncomfortable cushion, their neck hurts.	The neck cushion is poorly designed and does not fit the proper neck posture, resulting in frequent coughing and suffocation.
Axial Codes	The patient's neck was hurting due to a lack of ergonomic elements in the neck cushion.	The patient frequently coughing and suffocation due to improper neck posture, resulted from the lack of ergonomic elements in the neck cushion.
Selective Codes	The paddings were not ergonomically designed to compliant with patients' necks (unstable head positioning). Causes frequent coughing and suffocation.	

Findings and Analysis

Table 2 (part 1)

Findings and Analysis of Interviews

Activity of Daily Living	Findings and Analysis	Sample of Direct Quote of The Interview
Sitting	<p>Spend most of the day lying on the bed.</p> <ul style="list-style-type: none"> - Location: Living room/bedroom - Bed criteria: Conventional bed (pillow as a barrier) /baby bed (with wood barrier) - The pillow being adjusted upwards to let the CP patient watching television. - The ASO will be used for transporting only. 	<p>1. <i>"Since I'll be working in the kitchen all the time, we'll put him on his ASO and leave him in the living room watching tv with an adjusted pillow, where I'll be able to keep an eye on him...."</i> (Respondent 6)</p> <p>2. <i>"We usually just let her lie on the bed, but we make sure there is a barrier in place to keep her from falling out"</i>. (Respondent 10)</p> <p>3. <i>"We just used the ASO for transportation and rarely used it in the house"</i>. (Respondent 7)</p>

Table 2 (part 2)

Findings and Analysis of Interviews

Activity of Daily Living	Findings and Analysis	Sample of Direct Quote of The Interview
Sitting	<p>Headrest Padding</p> <ul style="list-style-type: none"> - The paddings were not ergonomically designed to compliant with patients' necks (unstable head positioning). Causes frequent coughing and suffocation. - Low quality paddings, foam is not sturdy and too soft. - Cushion/pillow was used as substitute to ensure comfortability. 	<p>1. <i>"His neck will suffer the longer he sits. The neck cushioning is insufficiently comfy."</i> (Respondent 1)</p> <p>2. <i>"Every time he sits, his neck appears to be out of position, resulting in frequent coughing and suffocation."</i> (Respondent 2)</p> <p>3. <i>"To guarantee a good head posture and comfortability, I constantly have to add a pillow."</i> (Respondent 3)</p>
	<p>Torso and Waist Padding</p> <ul style="list-style-type: none"> - The paddings were not ergonomically designed to compliant with patients' torso and waist. The paddings did not hold the torso and waist firmly. - Low quality paddings, foam is not sturdy and too soft. - The CP patient involuntarily tends to slide sideways, downward and forwards. - Affecting the back bones, long term effects: Scoliosis 	<p>1. <i>"The waist paddings are of poor quality... they are not strong and are excessively soft."</i> (Respondent 3)</p> <p>2. <i>"He regularly slides sideways because the waist padding is not firm enough."</i> (Respondent 4)</p>
	<p>Below Limbs Padding</p> <ul style="list-style-type: none"> - Unstable knee flexion due to the decreased postural control. - Low quality paddings, foam is not sturdy and too soft. 	<p>1. <i>"He lost his postural control, which resulted in an unsteady knee flexion."</i> (Respondent 5)</p>
Transferring	<p>Extremely difficult to manage the ASO for transferring.</p> <ul style="list-style-type: none"> - Impossible to carry, fold and move the ASO due to heavy and bulky ASO design. Certain parts on ASO need to be setup based on priority to overcome the issue. - Certain parts of the ASO are easily broken or destroyed. 	<p>1. <i>"We, as parents, are growing old and unable to cope with this bulky and heavy design"</i>. (Respondent 8)</p> <p>2. <i>"I will not fully configure the ASO because it takes a long time and is difficult to do, and we need to tailor it to the priority."</i> (Respondent 2)</p> <p>3. <i>"Every time I tried to prepare the ASO for him, there was a component that would break..."</i> (Respondent 9)</p>

Table 2 (part 3)

Findings and Analysis of Interviews

Activity of Daily Living	Findings and Analysis	Sample of Direct Quote of The Interview
Transferring	Extremely difficult to transfer the CP patient from the bed, car, and toilet to the ASO or from the ASO to the bed, car, and toilet. Difficult to handle due to regular seizures happened to the patient.	1. <i>"It's quite difficult to get him from his bed to the toilet or into a car."</i> (Respondent 3) 2. <i>"She will regularly have a seizure, which makes it difficult for me to transfer her from the bed to the car, or to the bathroom..."</i> (Respondent 10)
	Parents/guardians manually lift the patient for transferring. Caused back pain and slip disc.	1. <i>"We, as parents, are growing old and unable to cope with this bulky and heavy design... when I'm performing the transferring, it hurts my back."</i> (Respondent 8) 2. <i>"Three years ago, I was diagnosed with a slip disc as a result of my frequent manual lifting."</i> (Respondent 1)
Cleaning/ Bath	Due to a bulky and heavy design of ASO, the CP patients were being lifted by parents/guardians to the toilet/bathroom.	1. <i>"I have to manually lift her to the toilet since the ASO is heavy and bulky."</i> (Respondent 10) 2. <i>"I can't work with the heavy and bulky ASO, so I'll just lift him to the restroom manually."</i> (Respondent 3)
	Cleaning/ baths the CP patients in the toilet was found to be very challenging. - The process of cleaning/bath will be much more difficult and exhausted due to patient restraining or having a seizure. This resulted in a slippery and a series of falls. - Parents/guardians preferred to do the cleaning/bath process once a day while the patient is lying on the bed. - Pampers, water spray, water in the basin and wet napkin were used during the process (on the bed). Resulted in hygiene issues and bacterial infections among the patients.	1. <i>"She will be restraining because of the seizure that occurs regularly, especially while cleaning or having a bath, and it is risky since the tiles are slippery... me and her always fall in the bathroom."</i> (Respondent 10) 2. <i>"I'd rather clean him while he's on the bed, once a day so I used the cleaning wipes... However, there will be issues with hygiene and bacterial infection from time to time."</i> (Respondent 7) 3. <i>"I usually put on a pampers on him and clean him with a water spray or a wet napkin."</i> (Respondent 5)

Table 2 (part 4)

Findings and Analysis of Interviews

Activity of Daily Living	Findings and Analysis	Sample of Direct Quote of The Interview
Cleaning/ Bath	Plastic chair/netted chair/ lazy chair was used in the cleaning/ bath process.	1. <i>"To clean my son, my spouse placed a lazy chair in the bathroom."</i> (Respondent 2) 2. <i>"We purchased a netting chair and put it in the bathroom for him."</i> (Respondent 3)
	The current ASO is not water-resistant	1. <i>"I can't use water on the ASO since it's not water resistant."</i> (Respondent 2) 2. <i>"I tried to clean him on the ASO, but it ended up being a bad idea because the water ruined the seat."</i> (Respondent 5)
	The current ASO have no options available to physically positioned/ adjusted the CP patient to compliant the cleaning/bath process.	1. <i>"Cleaning him on the ASO is difficult since there is no way to adjust their position on the ASO."</i> (Respondent 7)
Dressing/ Undressing	Extremely difficult to dressing/ undressing CP patient in sitting position on the ASO. - CP patient tends to restrain or having seizure during the process. - As an alternative, most of parents/guardians dressing or undressing the CP patient on the bed	1. <i>"I occasionally dressed or undressed her on the ASO as well, but it is difficult due to restraining because she has seizures regularly. Hence, I prefer to do it on the bed"</i> (Respondent 10) 2. <i>"It was much more convenient for me to dress or undress him while he was resting on the bed."</i> (Respondent 6)
	Feeding	Severe level of spastic CP patient feed on liquid milk through machine attached to the ASO for every 2 hours. Milk is given to the CP patient on a daily basis.
Intermediate level of spastic CP patient feed on soft food with the help from parents/guardians		1. <i>"She can eat the soft regular food, just the same as ours"</i> (Respondent 10) 2. <i>"He can eat the soft regular food, but with our help to feed him."</i> (Respondent 5)

Table 2 (part 5)

Findings and Analysis of Interviews

Activity of Daily Living	Findings and Analysis	Sample of Direct Quote of The Interview
Feeding	Parents/guardian are not having ergonomic issue in feeding the CP patient on the ASO	1. <i>"When it comes to feeding him, I don't have any issues."</i> (Respondent 6)
Sleeping/ Napping	Regularly sleeping on the bed	1. <i>"Normally, I will place him in the bed with me at night."</i> (Respondent 8) 2. <i>"At night, he'll sleep on the bed."</i> (Respondent 2)
	Occasionally taking a nap on ASO when they were outside. - ASO cannot be adjusted to meet comfortable napping position - The body and waist paddings fail to firmly support the patient's body when sleeping, resulting in sideways or downwards slipping. - The neck paddings fail to conform to patients' necks when sleeping, resulting in repeated coughing and suffocation - Due to decreased flexor of the hip and knee, patient lost the postural control, and their legs are not in comfortable position.	1. <i>"He will take a sleep on the ASO from time to time, especially when it is outdoors. However, he finds it difficult to sleep on the ASO since he keeps falling sideways or downwards."</i> (Respondent 4) 2. <i>"His neck will suffer the longer he sits. The neck cushioning is insufficiently comfy."</i> (Respondent 1) 3. <i>"Every time he sits, his neck appears to be out of position, resulting in frequent coughing and suffocation."</i> (Respondent 2)

Finding and Analysis 1: Issues in Sitting Activity

Based on the interview, the majority of CP patients spend the significant amounts of time lying on the bed in the living room or the bedroom. As indicates by the parents/guardians, the ASO is only used for transportation purposes. Some parents/guardians will lift the pillow a bit higher to allow CP patients to watch television or to improve their comfort (Figure 5). A baby bed with a wood barrier was used to keep the CP patients from falling out of bed. In the case of a conventional bed, the parents/guardians would use a pillow to provide a barrier. When seated on the ASO, most parents/guardians report that the headrest padding is not comfortable for CP patients. Parents/guardians emphasized the stiffness of the headrest padding. The researchers have observed that the shape and size of the headrest paddings are not ergonomically designed to compliant with patients' necks, head and jaws, and low-quality foam was used in the design. Due to these issues as stated by the par-

ents/guardians, some CP patients had a regular series of severe coughing and suffocation. Many parents/guardians covered the headrest padding with additional cushion or pillow as a solution. In addition, the researchers have observed that most CP patients appeared to involuntarily slide sideways, downward and forwards while seated on the ASO. The condition arose due to the inadequate design and structure of the torso and the waist paddings, which did not secure the patient's body and waist tightly. As a result, some CP patients have developed scoliosis. In particular, due to the precarious flexion of the knee, the lower limbs of the CP patients were not in a stable position and causes comfortlessness.



» **Figure 5:** Additional pillow added to the headrest padding

Finding and Analysis 2: Issues in Transferring Activity

Transferring the CP patient from the bed, car, and toilet to ASO was found to be extremely difficult, according to the interview. The researchers have observed that the situation arose as a result of the current ASO's heavy and bulky design, which made it challenging to fold and move the ASO. In order to overcome the issue, certain parts on ASO must be attached or detached according to priority. Nevertheless, the researchers also discovered that due to repeated folding, certain parts of the current ASO are easily broken or destroyed. As an alternative, the majority of parents and guardians manually lift the CP patients for transferring but exposing themselves to back pain and disc slippage.

Finding and Analysis 3: Issues in Cleaning/Taking Bath Activity

Based on the interview, cleaning/ baths the CP patients in the toilet was found to be very challenging. As indicates in the previous section, due to a bulky and heavy design of ASO, most of the parents and guardians them-

selves lift the CP patients for transferring, which includes to the toilet/bathroom as well. In the toilet/bathroom, some of the parents/guardians will put the CP patients on plastic chair, netted chair or lazy chair. However, due to patient restrained or seizures, the process of cleaning/bath will be much more difficult, resulted in a slippery and a series of falls. Thus, some of the parents and guardians preferred to do the cleaning/bath process while the CP patient is lying on the bed. Diapers, water spray, water in the basin and wet napkin were used as an alternative when doing the cleaning/bath activity on the bed. However, this resulted in hygiene issues among the patients, leading to bacterial infections and other health implications. Based on the observation, the researchers discovered that due to non-water-resistant characteristics, the current ASO are not functionally appropriate for cleaning/taking baths, and there are no alternatives available to physically position/adjust the CP patient to comply with the cleaning/bath procedure.

Finding and Analysis 4: Issues in Dressing/Undressing Activity

Based on the interview, most of the parents/guardians indicates that it was difficult to dressing or undressing the CP patient when they are in sitting position on the ASO, and they tend to restrain or having seizure during the process. As the CP patient growing and become stronger, the restrain give a difficulty for the parents/guardians to handle them. As an alternative, the process of dressing or undressing the CP patient was executed on the bed.

Finding and Analysis 5: Issues in Feeding

Based on the interview, CP patients with a severe level of spastic condition feed on liquid milk via a system connected to the ASO every 2 hours (see Figure 6), while CP patients with an intermediate level of spastic condition feed on soft food with the aid of parents/guardians, according to the interview and observation. In terms of ergonomics, feeding the CP patient on the ASO is not a problem for the parents or guardians.



» **Figure 6:** *Liquid milk feeding machine connected to the ASO.*

Finding and Analysis 6: Issues in Sleeping/Napping Activity

According to the interview, CP patients sleep in their beds regularly and only use ASO to nap while they are outside, such as for a clinic visit. The ASO, however, cannot be adjusted to reach a comfortable napping position, based on the observation. As indicates by parent/guardians, the neck paddings fail to adhere to patients' necks when napping on the ASO, resulting in repeated coughing and suffocation. Furthermore, when napping on the ASO, the body and waist paddings struggle to firmly support the patient's body, resulting in sideways or downward sliding. Nonetheless, due to decreased flexor of the hip and knee, patient lost the postural control, and their legs are not in comfortable position while sleeping on ASO.

Discussion

Based on the previous literature, a study conducted by Angsupaisal et al. (2017), Bolas & Boyle (2017), Chung et al. (2008); Ries, Novacheck & Schwartz (2014), Rigby, Ryan & Campbell (2009), Ryan (2016), Sahinoglu, Coskun & Bek (2017), and Vekerdy (2007) have established that the ASO improves the occupational performance of CP patients to become more active during the intervention for a longer periods. Furthermore, the ASO allows the face-to-face social interactions, leading to increased sociability with family and friends. However, the use of ASO can be technically challenging for parents/guardians, as it did not provide adequate support or the stability required by the anthropometrics of Malaysian CP patients (Hui et al., 2011). Nevertheless, the average cost of funding for a patient's needs including purchasing the existing ASO are highly expensive especially for the bottom millions (Kamaralzaman et al., 2018). In relation to this current research objective, the results of the assessment have shown a multitude of issues faced by the parents/guardians in taking care of the CP patient especially during sitting, transferring, cleaning/bath and sleeping/napping, including the analysis of the ergonomic issues due to the technical aspect in the existing ASO. Furthermore, a lack of expertise and experience in dealing with CP patients among parents/guardian exacerbated the problems. Hence, a few design criteria were outlined with aims to improve the ASO design (see Table 3).

A high density of adjustable/flexible headrests with the shape and design that corresponds to the physical condition of the head, neck, and jaw will be implemented for the development of ASO design. These criteria are to ensure that CP patient's head can be placed in a comfortable resting position, to avoid frequent coughing and suffocation, to provide comfort, and to encourage positive movements of CP patient's head and neck.

The ASO will also feature high-density body and waist padding, as well as lumbar protection, backrest and side bolsters, and a four-point safety belt.

Table 3
Design Criteria to Improve the ASO Design Development

Design Criteria	Descriptions
High density of adjustable/flexible headrest with the shape and design corresponds to the physical condition of the head, neck and jaw.	<ul style="list-style-type: none"> i. Aim to comfortably rest CP patient's head and prevent the tendency of regular coughing and suffocation. ii. Aim to provide comfort and encourage positive movements of CP patient's head and neck.
High density of body and waist padding with lumbar support, backrest and side bolster, and 4-point safety belt.	<ul style="list-style-type: none"> i. Aim to stabilize the CP patient's body comfortably and firmly. ii. Aim to prevent the CP patient's tendency sliding to the sideways/downwards/ forward. iii. Aim to safely restraint the CP patient when having regular seizures.
Adjustable lower limbs supporter and separator	<ul style="list-style-type: none"> i. Aim to stabilize and solve the unstable knee flexion of the CP patient's lower limbs.
Simple folding mechanism and space saving, with lighter and durable material used	<ul style="list-style-type: none"> i. Aim to provide an easy and space saving storage through a simple folding mechanism. ii. Aim to provide a lighter ASO with a quality material used.
Lifting and Transferring assist features	<ul style="list-style-type: none"> i. Aim to enhance safety elements for both parents/guardians during lifting and transferring process. ii. Aim to provide a proper lifting and transferring process from the bed, car, and toilet to the ASO or from the ASO to the bed, car, and toilet.
Easy cleaning mechanism with water flowing and resistant features.	<ul style="list-style-type: none"> i. Aim to reduce the needs of lifting and transferring to the toilet by providing an alternative to do the simple cleaning process while sitting on the ASO. ii. Aim to ensuring a good hygiene
Visually aesthetic	<ul style="list-style-type: none"> i. Aim to boost confidence level, reduce the detrimental effect, tension and stress among parents/guardian and patients through the quality of aesthetic appeal in ASO design. ii. Aim to the provide appropriate comfort of the patients' psychological and physiological response.

These criteria are intended to keep the CP patient's body stable and secure while sitting, to avoid the CP patient's involuntary sliding to the side, downwards, or forward, and to securely restrain the CP patient while having recurrent seizures. Furthermore, an adjustable lower limbs supporter and separator will be included to stabilize and overcome the CP patient's lower limbs' unstable knee flexion. Nevertheless, an easy folding feature with a lighter and durable material will be introduced as well, with the goal of providing a lighter ASO with high quality material and efficient space saving purposes. With regards to ensure the safety for both patients and parents/guardians, lifting and transferring assist feature will be implemented to provide a proper lifting and transferring process from the ASO to the bed, car, and toilet or from the bed, car, and toilet to the ASO. Finally, the ASO will be fitted with an easy cleaning system that includes water flowing and resistant features, with the goals of reducing the need for lifting and moving to the toilet, providing an alternative to doing the basic cleaning process while sitting on the ASO, and maintaining good hygiene.

Conclusion

Based on the findings and analysis, the aims of this study have been met; 1) to determine the technical difficulties faced by the parents/guardians in taking care of the CP patient; and (2) to analyse the ergonomic issues due to the technical aspect in the existing ASO support. Based on the results of interview and observation, it can be concluded that there are various ergonomic and technical issues in the existing ASO including a series of challenges experience by the parents/guardians in taking care of the CP patient. Furthermore, throughout the research process, the implementation of ergonomics ergo-system and the framework of design needs assessment is beneficial to incorporate the CP's orthotic needs. The implication of this study helps the researchers to establish significant design criteria for the development of ASO designs in the near future, which in line with one of the Six Strategies Trusts in Eleventh Malaysia Plan (RMK-11); to enhance the well-being of Malaysian people (particularly in the B40 group) by providing better healthcare.

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