USER SPECIFIC INDIGENOUS COST-EFFECTIVE CUSTOMIZED MOBILE ARM SUPPORT

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Abstract

Background:

Spinal cord injury has become one of the most common conditions in the field of rehabilitation. The injury can happen at any level of the spinal cord and can be classified as complete injury or incomplete, meaning some nervous signals are able to travel past the injured area of the cord. Existing rehabilitation device called mobile arm support (MAS) is used to perform all ADLs independently for the Tetraplegia patients, hemiplegic, muscular dystrophy and upper limb weakness patients. But the cost of the device is not affordable to all the individuals to get benefited.

Aim:

To design and to check the effectiveness of a modified cost-effective MAS in performing ADL for spinal cord injury (SCI),Traumatic Brain Injury (TBI) & Cerebrovascular Accident (CVA) and to test the functional abilities done by the individuals independently in the device.

Method:

Two participants were enrolled in the study. Subjects were selected as per the inclusion and exclusion criteria. ADL and recreational activities of individuals with hemiplegia and upper limb weakness were assessed with help of cost-effective custom-made MAS. The customized model included gear and locking mechanisms which enables the users to keep the Upper Extremity in desired position to carry out different tasks. Verbal feedback and observation method were adopted for the outcome evaluation.

Results:

The current study results reported various advantages post use of MAS which included of reduction in spasticity, proper positioning of the upper limb for attaining functional grasp. Improvements in the ability to lift and move the arm with use of MAS were also reported subjectively by the participants.

Conclusion:

The cost-effective custom-made MAS satisfactorily met the objectives of the study. Recruitment of large no of participants, improvisation of the mechanism i.e. utilisation of spring mechanism or rubber band mechanism, quantitative assessment via standardised hand function scale will be useful for the more generalized evidence and improved user acceptability.

Keywords: Tetraplegia, Mobile Arm Support, Cost effective Activities of Daily Living.

1. Introduction:

Traumatic spinal cord injury (SCI) is a life-threatening incidence which disturbs sensory, motor or autonomic function that influences the major impairments on person's physical, psychological and social well-being activities in their life and sometimes high risk of mortality. [1-2] Tetraplegic patients with a lesion on low level cervical injuries endure with muscle weakness and impaired / limited Range of motions in upper extremity. Weakness of upper extremity motor movements results in incremental dependency in functional task augmentation. [3] Due to these conditions, the proximal musculature gets affected initially followed by the distal aspects resulting in activation of hand movements and inability to lift the limb by achieving the midline activities. Apart from the spinal cord injury other categories like Neuromuscular conditions (NMCs) are also more prone to cause bilateral upper extremity weakness.[4]The treatment and rehabilitation period are long and expensive and utmost early rehabilitation is essential to prevent joint contracture, regaining the muscle strength etc. To overcome the difficulty during rehabilitation, assistive devices are most helpful to perform Activities of Daily Living (ADLs). Appropriate upper extremity with skilful hand function is a mandate for daily interaction with the environment and community. Recovery and restoration of all these functions is highly essential by keeping the independence of patients with tetraplegia as an important priority. A great potential for improving the quality of life after higher level spinal cord injury can be achieved by continuous rehabilitation.[5]With up gradation and advancements in medical care for individuals with SCI, the enhancement in probability of life expectancy has uplifted. Additionally rehabilitative approach adds the ease and quality to the rest of the life after SCI.

The goals of upper limb intervention with mid cervical level tetraplegia are to prevent and control the development of deformities, protect the site of injury, prevent or reduce edema and maintain a supple hand for human contact. Simple devices with low technology are the most widely prescribed interventions for maintaining the gravity-eliminated wrist extension or anti-gravity wrist extension strength of the survivors. A wide variety of orthoses address for the appropriate positioning and correction of the deformities. These interventions include the resting Wrist Hand Orthosis (WHO), static progressive WHO and dynamic WHO, universal cuffs etc.Feeder is a specialised device used to support weight of the arm and permits the patient with severely weakened/paralysed upper extremities to position the hand with a minimal of muscular effort. These devices utilize the residual strength of the wrist and augment it in an appropriate functional direction. As self-explanatory, it facilitates the shoulder and elbow motions required for feeding, hence referred to as "feeder". Inclusion of feeder devices i.e. supportive and suspension feeders improvises and supports the alterations achieved by the orthotic intervention in terms of facilitating independent ADL.

The Mobile Arm Support (MAS) is a simple, technically advanced apparatus which completely support the arm thus allowing it to make use of its residual for functional strength. The MAS supports shoulder Flexion and abduction in a desired anti-gravity position and to assist the internal and external rotation of shoulder. MAS is a mechanical device which provide the functional assistance to the shoulder and elbow motions with the features of friction the linkage system. The device helps to provide operational movements with a pattern of horizontal abduction and adduction of shoulder motion which helps to achieve the hand-to- body activities and vertical pattern of movements of hand-to-face motions to activate shoulder and elbow joints in sagittal plane activation. [(3)]Lapboard can be used additionally to counteract or perform eating and table top activities with the movable linkage system.It primarily achieves independence in feeding as well as to assist activities like grooming, writing, house hold tasks and recreational activities. Varies of feeders/ MAS are available in commercial markets which includes both powered and non- powered facilities. However, non-powered MAS like foot operated feeder by Georgia Warm Springs Foundation in 1936[(6)], Barker Feeder, Saebo MAS,Jaeco MAS[(7,8)]around 1950 were available in commercial markets, and powered feeders like Winsford Feeder, Meal Buddy feeder,JAECO Robotic arm,i-Arm,WREX[(9),] ARMON[(10)]and Freebal[(11),]respectively. The above-mentioned feeders are high in cost for the individuals to purchase for the rehabilitation and home care task. The purpose of this research is to design and develop the cost-effective MAS for the tetraplegic patients to utilize for the rehabilitation periods and home care activities. We hypothesized that the economically installed and adjusted MAS will have a notable result in enabling patients to perform self-care, vocational and recreational activities. The main objective of this design analysis concept is to decrease the dependency on family and hospital personnel.

2. Materials & Methods:

2.1 Study design and setting

The ethical committee of Mobility India Rehabilitation research and Training Centre (MIRRTC) approved this study. Participants were aware of their research involvement and written consent was obtained before their participation. This study has been designed as a clinical case report for prototype designing and application.

2.2 Participants

Two participants were recruited for the study from the Therapeutics department of the institution following inclusion and exclusion criteria. The participants who met the inclusion criteria were up to 70 years of age, diagnosed with traumatic brain injury (TBI), spinal cord injury (SCI) i.e. C4-C7 Tetraplegia & upper limb weakness. The participants who were unable to sit upright for 30 minutes and can't able understand the commands were excluded from the study.

2.3 Design Concept

The concept of the design in based upon the feeder devices which are specifically used for performing various ADL independently. It can be fixed with wheelchair used by the patient and fixed with chairs. The Mobile Arm Support consists of components like MAS mount, movable arm, and forearm part. The design feature included the sliding mechanism in the forearm part to slide front and back and the swivel mechanism. This allows the patients to reach and grasp the objects to do their ADL.

2.4 MAS Componentory

Fabrication of the MAS included the versatility of a wide range of raw material, components and equipment. The materials included aluminium alloy pipe, wing nuts, 5 mm thickness aluminium bar, modified screws and nuts etc.

The MAS included various parts which were assembled together to give a target-oriented function i.e. Movable arm, Sliding and swivel clamp, forearm part, spirit level and rod, adjustable pipe clamp.

2.5 Fabrication Procedure

Various parts of MAS were designed with intricate precision and accuracy so that the therapeutic as well as independent ADL performance can be well driven.

2.5.1 Forearm part

The forearm part was designed as a universal size so that it can be used for everyone. Velcro straps were attached to secure the user's elbow, additionally elbow stopper supported it from further misplacement. (Figure 1)

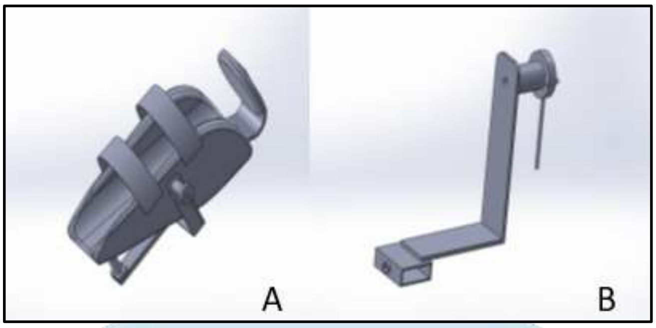

Figure 1: Forearm assembly with sliding & swivel mechanism

2.5.2Fabrication of Sliding Mechanism:

The aluminum flat was taken according to the length of the elbow cuff and attached at the bottom. To augment the sliding adjustment in front and back and the locking system in appropriate position the wing screw nuts were utilized.

2.5.3Fabrication of Swivel mechanism:

The swivel mechanism is (rotatable) is fixed to the inverted L angle. The inverted L angle is attached to the base of the sliding lock. The swivel mechanism is attached with the vertical rod which holds on to the distal moveable arm.

2.5.4 Fabrication of moveable arm

An aluminum bar was taken and cut into 3 parts i.e. proximal arm, mid arm, distal arm. A round shape polypropylene sheet was cut into four pieces which can act as dial lock mechanism. A dial lock mechanism was fitted in between every moveable arm so that only flexion and extension movement will be allowed and hyperextension movement will be restricted.

2.5.5 MAS mount:

This MAS mount included a gear mechanism which allowed adjustment in anterior, posterior and medio lateral direction. The MAS mount was made to be fixed in the wheelchair with a portable arm section.

Figure 2: Assembled MAS in wheel chair

2.5.6 Fixing rod

The main function of the fixing rod was to connect the clamp and the proximal movable arm for facilitating rotation movement. The fixing rod consisted of multiple holes according the patient's height for adjustment.

3. Results:

MAS have a long history of development and wide field of application to benefit users with upper limb impairments. The MAS can provide tremendous functional gains, including self-feeding, grooming, tabletop activities, and wheelchair control (Figure 2). In spite of these benefits, application of the devices has decreased due to certain reasons such as high cost and cumbersome usability. This study has aimed to design and develop a user-friendly cost-effective design of a MAS which improved the functionality of ADL.The impactful characteristic incorporated in it is the designing of the model out of surrounding available components along with its affordable cost.

Trial was taken with two participants (Figure 3) and it was revealed that they were able to achieve the joint motion required to perform the ADL activities. Both can perform some of the ADL effectively according to the available muscle strength. There were certain difficulties faced by the users due to the heavy weight of the forearm piece. Both the users were quite satisfied with ROM and strength they can build during the therapeutic sessions with the new MAS model.

Figure 3: The usability of MAS with participants for desired tasks

4. Discussion:

Owing to the complexity of rehabilitation and restoration of the UE following a cervical SCI, traumatic brain injury (TBI) and cerebrovascular accident (CVA) it is difficult to attain high levels of activity and maintain typical kinematics. To further complicate the UE rehabilitation process after paralysis, there is no standard protocol of interventions in the therapeutic or surgical arenas. Functional electrical stimulations one therapeutic intervention being used to perform specific movement pattern and complete functional tasks that would otherwise be unobtainable [12-14]. Research has shown that combining task-specific training with electrical stimulation yields better results in terms of neurological and functional improvements than either of them alone[15].

This case study provides initial insights into the experience of individuals with motor and sensory impairments following SCI, TBI and CVA regarding the impact of using simple and cost-effective MAS for participation in ADL.

Cruz et al[16] recruited 9 patients suffering from Duchenne muscular dystrophy (DMD) and studied their experience while utilizing non-powered MAS for ADLs as their disease progresses. The main benefit reported by the participants was a reduction in fatigue and improved endurance in daily tasks. The current study results are in par with the previous study by adding the advantages of reduction in spasticity, proper positioning of the upper limb for attaining functional grasp. Improvements in the ability to lift and move the arm with use of MAS were also reported subjectively by the participants.

5. Limitation:

There are some limitations that should be noted in this study. The small sample size of this study limits generalizability of the results. The heavy weight of the forearm part resulted in indulging more effort for operating the MAS.Qualitative assessment utilizing various hand function scales were lacking for this particular study.

6. Future Recommendations:

Further research is needed to understand the level of strength required to effectively use a non-powered MAS. This information is necessary to guide prescription of MAS and funding decisions.Experimentation can be done by using spring mechanism and rubber band mechanism which has a tension on the moveable arm to assist for gravity eliminated position. Improvement in different componentory of MAS within the cost-effective limit is warranted for improved user compliance.

7. Conclusion

The use of MAS was found to enhance upper limb function and independence with ADLs for the participants. Further outcome measures and scales substitutions along with quality-of-life assessment of users can add new direction for development of an user friendly cost effective MAS.

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