# Development of Exoskeleton Robotic Leg (ExRoLEG) for Kids with Cerebral Palsy

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**ABSTRACT** – Cerebral palsy is a neurological disorder that happens to a child's brain due to injury or malfunction during growth. This primarily affects body movement and muscle coordination. Our exoskeleton robotic leg, (ExRoLEG) aims to act as a rehabilitation device that supports children with cerebral palsy to walk. This includes walking posture, walking pattern and strengthening. This study focusses on the development of exoskeleton robotic leg for allowing kids with cerebral palsy disorder to achieve early walking independent age compared to conventional methods. Various factors are considered to avoid risks or failures including materials, safety, engineering calculations and user friendliness.

## 1. INTRODUCTION

Cerebral palsy is a neurological disorder that results from a non-progressive brain injury or malfunction. It affects a person's body movement and muscle coordination. Cerebral palsy is mainly divided into two groups: spastic and non-spastic. ExRoLEG is built for patients with spastic cerebral palsy that accounts for almost 70% - 80% of all diagnosed cerebral palsy cases [3].

Severity of cerebral palsy is classified based on Gross Motor Function Classification System (GMFCS) that consists of 5 levels in total [1,2]. GMFCS Level I – gaits without any limitations. GMFCS Level II – gaits with limitations such as walking for long distances. Patients may require mobility devices when learning to walk for the first time, usually, prior to age 4 and may rely on wheeled mobility equipment for outdoor activities and traveling long distances. GMFCS Level III – gaits with adaptive equipment assistance. This level requires hand-held mobility assistance to walk indoors, utilizes wheeled mobility outdoors and can sit on their own with limited external supports. GMFCS Level IV – self-mobility with the use of powered mobility assistance. It usually involves support when sitting, restricted self-mobility and likely to be transported in manual wheelchair or powered mobility. GMFCS Level V – This is the most severe category where patients experience head and trunk control restrictions. Patients of this level require extensive use of assisted technology and physical assistance and transported in a manual wheelchair [4], unless self-mobility can be achieved by learning to operate a powered wheelchair.

In this study, we focus on Level II and III, targeting patients with: limitation to walk for long distances, mobility device assistance when learning to walk for the first time and hand-held mobility assistance to walk.

## 2. METHODOLOGY

ExRoLEG is mainly built from metals and controlled by Arduino system. Metals used in this project are 2mm galvanized iron sheet metal and aluminum plate.

Aluminum plate is cut into 30 X 220mm dimension for upper leg and 30 X 240mm for lower leg. Sheet metal is cut into various compatible designs for waist plate, foot plate, upper knee joint and lower knee joints. The processes involved for fabrication are sheet metal shearing, bending, drilling, cutting and finishing. Most of the cutting processes are done by abrasive cutting with a grinder.

All of the parts are joined by bolts and nuts. Linear actuator and power window motor are assembled at the knee joint to control the motion. In arduino system, EMG or limit switch (optional) functions as the control mechanism that gives analog input.

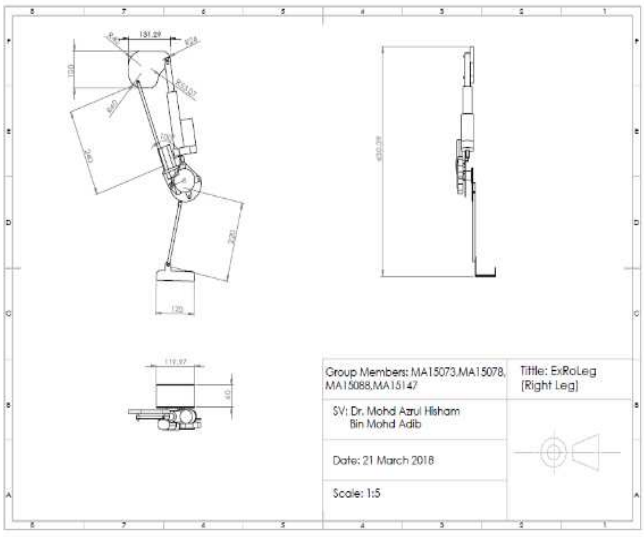


Figure 1 Drawing of ExRoLEG (Right Leg)

## 3. RESULT AND DISCUSSION

In Figure 2, the rectangular grey sheet metal is attached to the waist belt which is connected to the aluminum bar that acts as a support for the thigh. The following heptagonal sheet metal represents the knee joint that is fixed to another aluminum bar that reaches all the way to the feet. An electrical actuator is responsible to lift the weight of the entire leg and a power motor is used to bend the knees. The movement of our exoskeleton is mostly automated, controlled by an Arduino system.

The electrical actuator and power motor are power-hungry devices. Therefore, it requires more DC power supply to operate and better motor driver module to withstand the high-power rating. If lower specifications are used, the circuit might get burned or the devices will not operate optimally due to the lack of power supply.

Figure 2 ExRoLEG device

By default, the entire transmission mechanism can simply work with 2 electrical actuators. The assembly is much easier compared to the current design. However, in terms of cost, the cost of a unit of electrical actuator is 3 times higher than the cost of a unit of power motor. In addition to the engineering calculation, electrical actuator can support higher load in comparison to power motor but the possible load applied to the power motor is sufficient for its function.

In term of structure, design needs to be always updated due to errors during fabrication. Most of the metal works involve simple geometries but some parts require skills and innovation to produce the specific parts. Last but not least, the weight of the whole product itself is approximately 4kg per ExRoLEG. This is pretty heavy and assistance is needed to utilize this product.

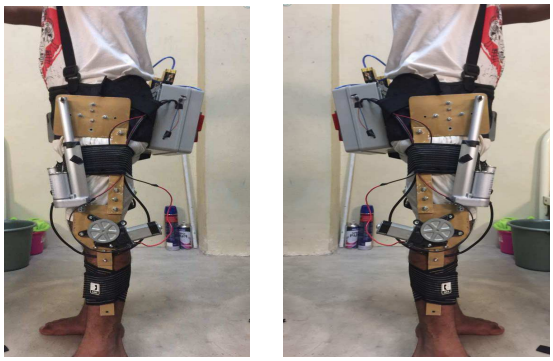

Figure 3 ExRoLEG fitting on patient

## 4. CONCLUSIONS

New technologies are being created every day to enhance the living quality of people's life making this project an applicable and essential innovation to mankind. Aspects such as market pricing, durability, safety and amenities are taken into consideration and incorporated at its best quality into ExRoEG. In order to achieve our best product, every detail in our concept design is scrutinized thoroughly such as ExRoLEG's transmission mechanism, type of strap, frame structure, sating material, control system, etc. Since ExRoLEG focuses on rehabilitating people suffering from gait issues, their dream of walking normally and independently one day, will be brighter. However, there are rooms for improvement in order to provide the best quality and performance for the patients.

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## REFERENCES

[1] Cerebral Palsy Guide, *Assistive Technology for Limited Clinical Mobility Issues*, 2016.
[2] Cerebral Palsy Guidance, *Cerebral Palsy and Pain*, n.d.
[3] E. Matchar, *This Robotic Exoskeleton Helps Kids with Cerebral Palsy Walk Upright*, 2017.
[4] R. Palisano, P. Rosenbaum, S. Walter, D. Russell, E. Wood, and B. Galuppi, *Developmental Medicine and Child Neurology*, vol. 39, no. pp. 214-223, 1997.
[5] Z.F. Lerner, D.L. Damiano, T.C Bulea, *Science Translational Medicine*, vol. 9, no. 404, 2017.