Review of Active orthosis for lower body disabilities

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Abstract – Mechanism which is wearable and can be used for providing assistance and mobility to the disabled can be termed as exoskeleton. As the Assistive technologies demand is increasing day by the, the importance of wearable technologies in on the rise especially for the ageing group. Thus it is important to study the assistive technologies that can help in achieving mobility for the disabled, the majority of which belong to older age group. This paper covers the overall review of different types of exoskeleton which are specifically designed for the medical applications.

Keywords — Assistance, Disabled, Mechanism, Mobility, Technologies, Wearable.

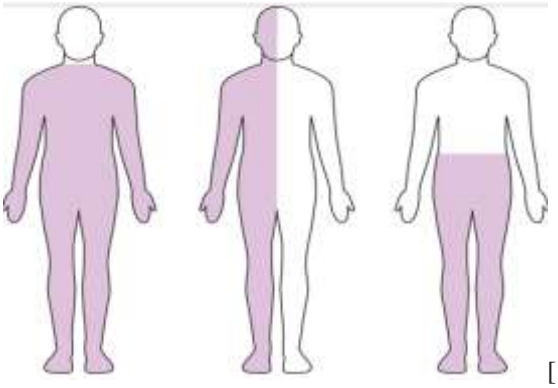
I. INTRODUCTION

Different types of exoskeleton are designed as per the requirement. Some are built for escalating the physical performance of the wearer. Some are built with the aim of increasing the speed of the repetitive work. Some help disabled people in achieving mobility. Thus it is important at first to know the requirement for which the exoskeleton has to be designed.

Paraplegia is a medical word for a person who is paralyzed from the waist down that means the person cannot move his/her legs or any other part below the waist, and do not have any feelings in those areas either. This condition is developed due to damage to the spinal cord because of disease or an accident and the people suffering from this condition are called as Paraplegics

Further the spinal cord injuries are divided into four main broad categories; which are C (C1-C4 & C5-C8), T (T1-T5 & T6-T12), L (L1-L5) and S (S1-S5). Out of these patients with injuries in C1-C4 & C5-C8 are called quadriplegics (all four limbs affected) and patients with injuries in T1-T5 & T6-T12 are called paraplegics as defined above.

Orthosis which may be an active or powered one differs from an exoskeleton in the sense that orthoses generally refers to assistive devices to help people with disabilities walk while exoskeletons are the structures which are powered and allow for movement of limb with increased.



[1]

Fig 1- (a) (b) (c)

Fig 1 shows the different types of condition in the human body. (a) shows the quadriplegia, (b) shows hemiplegia, (c) shows paraplegia.

Exoskeletons which are used by the Paraplegic people for achieving mobility are studied in this paper. In total, 11 different types of exoskeleton are reviewed.

II. LITERATURE REVIEW

- **Review of Ekso [2]**

Fig 2 – Ekso Exoskeleton

This exoskeleton is actuated by hydraulic actuators. The weight of this exoskeleton is 20 kg. There are in total 6 DOF. The assistance levels are adjustable. It can achieve a peak torque of 150N.m. Its bag pack contains Battery, portable compressor. The sensors used in exoskeleton are encoders and linear accelerometers. The total battery life is of 6 hours.

Although assistance levels are variable which gives the required flexibility to the exoskeleton, the cost of exoskeleton limits its usage. Its total cost is more than $100,000. The wearers can range from 5 ft 6 in to 6ft 4 in and can weigh up to 100kg.

- **Review of ReWalk [3]**

Fig 3 – ReWalk Exoskeleton

This exoskeleton is actuated by DC Motors. The weight of this exoskeleton is 23 kg. Even though this exoskeleton helps in walking, Crutches have to be carried all the time when walking. Wrist-pad controller is provided to control the exoskeleton. The speed that this exoskeleton can achieve is up to 2.2Km/hr.

The Battery can drive it up to a maximum of 2h 40min. It can climb the Stairs, come down the stairs. There is also a normal walk mode which is used while walking on a flat terrain.

- **Indego [4]**

Fig 4 – Indego

This is one of the most light weight exoskeleton among all the existing exoskeleton. It weighs only 12kg. As it is light in weight, it can be easily worn and removed from the body. It is driven by DC brushless motors. Its operation is wireless and has a relatively less battery life. It is relatively easily to handle and has fewer control functions.

It comes in two versions, Indego personal and Indego therapy. It can be easily split into three pieces and then joined back to the original. As advanced materials are used, the cost of exoskeleton is very high. It costs around 140,000 USD in total.

- **Rex [5]**

Fig 5 – Rex Exoskeleton

This exoskeleton is actuated by linear actuators. No support stick is required when walking as this actuators has the ability to support entire human weight. However, the weight of this exoskeleton is 38 Kg which makes it difficult for locomotion at higher speeds. The torque requirement is on the higher side as it needs to handle the extra self-weight.

There is Joystick provided for the control of motion. It has a self- balancing system and a custom rechargeable battery which adds to the weight of the bot. It has a very high cost due to which its applications are limited. It has a Non-invasive brain interface technique which helps in data acquisition directly from brain.

- **Atlante [6]**

Fig 6 – Atlante Exoskeleton

This exoskeleton can achieve a total of 12 Degree of freedom. This makes the exoskeleton very flexible. Crutches and sticks are not required for mobility. They are driven by electric motors. It also has dynamic balancing control. It is a self-contained autonomous device.

The R&D was carried out by Wander Craft Ltd. Its battery lasts a maximum of 3 hrs. It costs on a relatively cheaper side, around 33000 USD in total.

- **Exo H2 [7]**

Fig 7 – Exo H2 Exoskeleton

ExoH2 is an exoskeleton made by Technaid. DC Motors are used for actuation of various parts of the exoskeleton and are run with the help of Lithium powered 22.5 V DC Battery. There is a 6 hours battery backup as well. All the Control parameters can be adjusted as per the patient needs.

The patient requires a support stick for autonomous walking for additional support.

It is a lightweight exoskeleton weighing 12kg. It can be connected to mobile via Bluetooth for control. It provides Limited assistance in sagittal plane via six motors mounted at hip, knee and ankle joints of both legs.

- **ExoAtlet [8]**

Fig 8 – ExoAtlet Exoskeleton

ExoAtlet22 exoskeleton consists of electric actuators for actuation .EMG and torque sensors are used for control. Just like ExoH2 Support sticks are needed. A bag pack is provided for supporting the batteries.

It's possible to climb stairs and can also be used for physiotherapy.

- **MindWalker [9]**

Fig 9 – MindWalker Exoskeleton

MindWalker is an exoskeleton which weighs around 30kgs. It uses linear electric actuators for actuation of various parts of the exoskeleton. It has 5 DOF at each leg and works on user command.

It takes into consideration the center of mass to control walking of the person. User needs to hold handrail for walking. While walking, Person is able to recover balance from external instability. Brain Neural computer interface based control system is being developed in this exoskeleton.

- **Exoskeleton by Univ. of Wisconsin [10]**

Fig 10 – Univ. of Wisconsin Exoskeleton

The 27.2 kg exoskeleton shown in the picture consists of rotary hydraulic actuators which are used to actuate various parts of the exoskeleton. It consists of universal joints at hip/knee. There are four actuators (two at knee, two at hip) and DC motor driven hydraulic pump. Further it also consists of Off-board computer for control. Moreover, just like ExoH2 Stick is needed for stability. It is very comfortable for the wearer to use it for long duration.

- **Tokyo Denki Univ. Orthosis [11]**

Fig 11 – Tikyo Denki University Orthosis

The weight of this orthosis is 19.7 Kg. It consists of bilateral hydraulic servo actuators which help to actuate various parts of the exoskeleton. Potentiometers are used for position control of orthosis. There are Pressure sensors in shoes to maintain posture of the body.

It has 4 DOF per leg and can also be used for gait training. It needs external hydraulic pump for power and can only be used under controlled lab conditions under supervision.

- **LOPES [12]**

Fig 12 – LOPES Exoskeleton

LOPES is designed for rehabilitation purpose. It has in total 8 DOF out of which 3 are at the hips. It is generally used for treadmill training. It has two modes – robot mode and patient mode.

It can move in parallel with the legs of a person walking on a treadmill. It uses impedance control strategy for its working. It uses series elastic actuator for actuation. It is generally used for rehabilitation purposes.

- **KNEXO [13]**

Fig 13 – KNEXO Exoskeleton

It is the model for rehabilitation purpose. Actuation system used is pleated pneumatic artificial muscles. It uses external compressor and has 1 DOF at knee joint. It can support up to 90 kg person. It provides zero torque mode for unassisted talking. It is light in weight.

It has artificial pneumatic muscle with full knee support for safe & compliant working. Need of pressurized air makes it less mobile. Trajectory controller is used which is interaction based. It has compliant human-robot interaction.

- **NE Univ. Orthosis[14]**

Fig 14 – North-eastern Univ. Orthosis

NE Univ. orthosis is developed in general for rehabilitation purpose. It is actuated by ERF variable damper system. It can be modified as commercial knee brace. It has aluminum design which is light in weight. It provides resistive torque for rehabilitation.

It uses electro- rheological fluid actuators which gives smaller, simpler & cost efficient solutions. IT can be also used by Astronauts.

- **AxoSuits [15]**

Fig 15 – AxoSuits Exoskeleton

This type of exoskeleton are actuated by electric actuators. They have a large battery life which can last up to a maximum of 6 hours. It has adjustable size for patient height and weight. It also ha adjustable recovery settings.

Its power consumption is on the lower side. Even though there is large battery life, it has compact batteries.

- **Modular Knee Exoskeleton [16]**

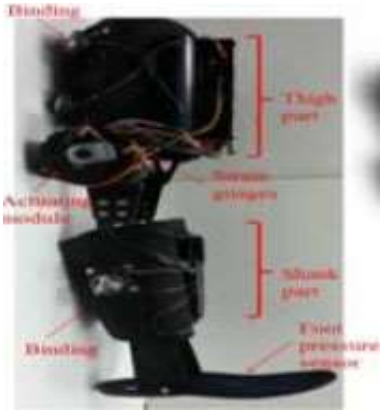


Fig 16 - Modular Knee Exoskeleton

Modular knee exo 3.7 model developed for paraplegic person. It is a DC actuated model. It has one DOF per knee. It has polycentric knee actuator motion with 4 force sensitive foot insole sensors.

It can be operated wirelessly and has LCD display. It has buzzer for notification. Motor driver has maximum power of 200W. It also has FSM - based control algorithm.

- **Quasi- passive lower limb type exoskeleton [17]**

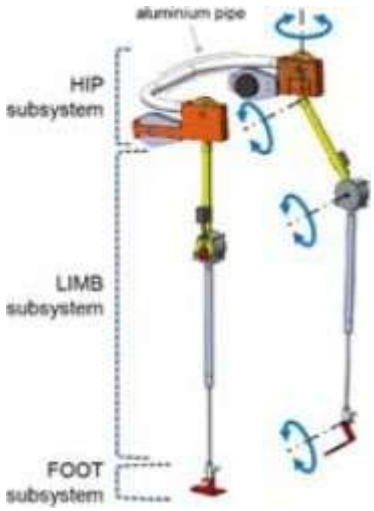


Fig 17 – Quasi- passive lower limb type exoskeleton

It is actuated by Solenoid actuators of 9-24 VDC. It is multipurpose model and can be used by elders, workers and able bodied. It is mainly useful for weak muscle person. It has 4 DOF. Provided with knee locking mechanism as per gait cycle.

It uses lightweight aluminum frame. Because of the use of aluminum in the main structure, the weight of the exoskeleton is reduced to a minimum of 9 kg. Main focus in development phase was on cost reduction due to which cheap actuators are used.

- **Self-adjusting isostatic exoskeleton [18]**

Fig 18 - Self-adjusting isostatic exoskeleton

This type of exoskeleton is actuated by DC motors. It has a maximum knee torque of 40 N-m. It also has Self-adjusting programmable torques to the articulation.

It has in total 6 Degree of freedom. It has metal support for thigh and shank housing.

III. CONCLUSION

The paper presents a review of lower-body wearable exoskeletons for people suffering from paraplegia. The exoskeletons have been paralleled to give understanding into their strategy and functionality from mechanical and electrical disciplines including key issues such as control, sensors, strategy, mechanisms and materials and powering methods. Literature survey is done for different types of exoskeletons considering the above various factors. It suggests various improvements needed to be done in the existing wearable exoskeletons and to allow for the research and development the focus should be made in the relevant technology areas for achieving more advances in the lower-limb exoskeletons domain. This article will help individuals in reviewing different types of exoskeletons and enable them in selecting the exoskeleton(s) according to their requirement.

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