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DESIGN OF ERGONOMIC CRUTCHES

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ABSTRACT

Crutches are medical devices designed to aid in ambulation, by transferring body weight from the legs to the torso and arms. They are mainly used to assist individuals with lower extremity injuries and/or neurological impairment. Prolonged use of crutches leads to the radial nerve, a part of the brachial plexus, being under constant pressure, which can lead to the paralysis of the innervated muscles. In this project we aim to reduce the possibility of crutch paralysis by proposing a design of an ergonomic crutch that will reduce the force acting in the user's palm, thus reducing the chances of crutch paralysis.

Keywords: Crutch, Ergonomic, Paralysis, Shock Absorber, Spring, Damper.

I. INTRODUCTION

Crutches are a type of walking aid to increase the size of an individual. It transfers weight between the legs and the upper body and is often used by people who can't support their legs (i.e., short-term injuries to lifelong disabilities). The use of those crutches in long run can cause crutch paralysis, this is due to the impact forces coming from the uneven surface where the patient is walking. here we have proposed the model in which these impact forces get eliminated through shock absorber. Also, we have added more couple of features that will help the patient to customize the crutches accordingly. we have taken the bare minimum for society to afford it easily.

II. METHODOLOGY

Let us have a look at the existing designs of the crutches. There are mainly three types of crutches available: Axillary, Elbow, and Gutter.

Axillary Crutches

Axillary crutches are employed while inserting the tube under the axilla and holding the grip below and parallel to the tube. They should be about 5 cm under the axilla, with the elbow bending about 15 degrees.

Limitations of Axillary Crutches: Axillary crutches imply higher force on the underarm, which results in paralysis in long run. Also, these crutches have limited upper body freedom. These crutches need significant upper body strength. These crutches are inconvenient to carry all the time.

Lofstrand Crutches

These crutches are frequently used for long-term injuries and diseases. They take more strength than underarm crutches, yet they regulate your movement more. Their usage on uneven landscapes and staircases is often easier.

Limitations of Lofstrand Crutches: Similar problems are faced as in underarm crutch. These crutched also require good stability and upper body strength. Light relief is added due to the elbow rest.

Gutter Crutches

These are supplementary crutches that consist of cushioned brackets made of metal, a strap, and rubber ferrules adjustable handpiece. These crutches are used for partially-weighted patients, such as rheumatoid disease.

Limitations of Gutter crutches: These crutches provide less lateral support due to the absence of an axillary pad. These are expensive as compared to other crutches. Also, cuffs may be difficult to remove.

Below is some supporting information regarding people using crutches.

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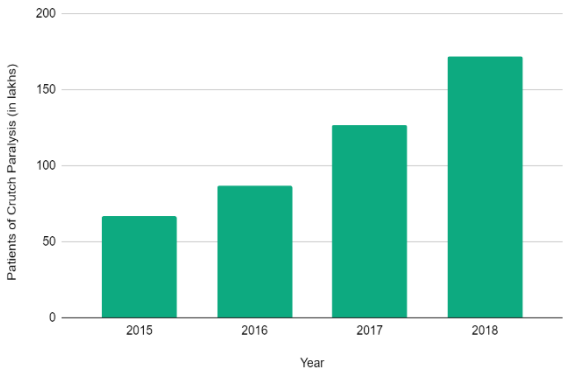

Figure 1: Number of Crutch Paralysis Patients in the year 2015, 2016, 2017, 2018.

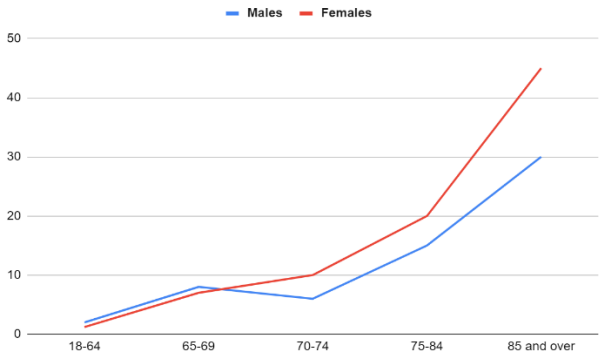

Figure 2: graph of Age e of people vs Percentage of people using crutches.

A brief explanation of the graph is given below:

Figure 1 shows that the patients with crutch paralysis in India were about 67 lakhs in 2015, 87 lakhs in 2016, 1.27 crore in 2017, and 1.7 crores in 2018. The rate of patients doubles almost in 3 years.

Figure 2 shows the percentage of people using crutches. The major use of crutches happens among the age group of 74 and above.

III. MODELING AND ANALYSIS

We have come up with a solution that majorly acts on eliminating the impact forces. We have attached the designed model. As you can see in figure 3, we have added a feature that will make this model which can be customized according to the patient. We have worked to make the crutch mobile, which will help people to carry it easily from one place to another. We have added a suspension at the end to act as a shock absorber and a cylindrical base at the bottom. Design shoes with spring at the base to facilitate motion and cause less fatigue in the forearms. We have made the crutch to be foldable to enhance its mobility.

The features of the proposed model are discussed below

Continuous Length selection

The crutches that are available in the market come with 5-6 options for length variation. This creates discomfort for most of the users as the preferred length is not available. As we can see in figure 3, we have added an extendable rod to the crutch body so that analog length is achievable.

Figure 3: Length selection

Foldable

We have made the design foldable for easy mobility of crutches, which we can carry in our bags if there is no need for it. There is a threefold stick with an attached tie to it as shown in figure 4. The first fold comprises of the arm wrist, the second part was of Continuous Length Mechanism and the last part was of the suspension mechanism.

Figure 4: Proposed Model

Spring-Damper System

As shown in figure 5, a spring with a damper is added to the base of the crutch to absorb the impulse acting on the hand. Spring and damper system leads to a significant reduction in the rate of application of force on the palm of the user. Thus, the total fatigue experienced by the user reduces significantly.

Cylindrical Base

Figure 5: Foldable Design

We propose to add a cylindrical base to the crutch to increase the duration of contact of the crutch with the ground as well as the area, as shown in figure 3 The increased duration of momentum change results in a lower value of jerks experienced at each step. Also, the proposed design will provide better stability.

External Accessories

Adding a spring at the feet of the user will reduce the normal reaction acting on the palms while rising. The energy stored in the compressed spring will be utilized to raise the potential energy of the user, thus reducing the force acting on the palms of the user. We propose using spring shoes as an added accessory to reduce the force, thus reducing the extent of fatigue and crutch paralysis.

Material Used and its Properties

We would be using GFRP (Glass Fiber Reinforced Polymer) as the material to develop the crutch. GFRP is a synthetic amalgamated material composed of plastic and ultra-fine fibers of glass, usually known as fiberglass. In comparison to carbon and other metal fibers composites, GFRP is a relatively cheap composite material.

GFRP has high strength, low cost, high durability, and corrosion-resistant. GFRP is a light weight composite that has low maintenance.

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IV. RESULTS AND DISCUSSION

Let us have a look on the outcome of adding a shock absorber in the crutch. In Figure 6 shown below, we see the response of the system (shock absorber) via a MATLAB code and it has come to be a natural response with time. Initially, there is large variations in the amplitudes, but it came to be constant over the time.

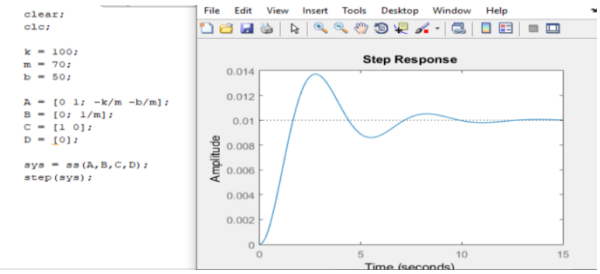

Figure 6: The response of spring damper system

The normal cost of gutter crutches is eventually high in that cause we did a cause analysis of the designed crutch with shock absorber and various attachments. Thus, the estimated cost given in the Table 1.

Table 1. Estimated Cost

S.NO.	Segment	Cost (in Rs.)
1.	Material	200
2.	Damper	100
3.	Extendable Rod	150
4.	Elbow Rest & Base	150
	Total Cost	1200 (for a pair of crutches)

Thus, we have tried to be minimal with the cost which will approximately Rupees Twelve hundred Rupees for a pair of crutches.

V. CONCLUSION

We came across the limitations of present crutches, our design will mainly focus on eliminating impact forces caused by present design. Also, the proposed model is easy to carry as it is foldable and has a feature of variable length. Here, we have tried to be economical with the ergonomic crutch which will help people to afford it easily and will work best in favor of society.

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