Axillary Crutches with Flexible tip for Reduced Energy and Zero Side effects

Figure 1: Flexcrutch with the biomimic tip

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Abstract

Axillary crutches are one of the most widely and commonly used assistive device. The traditional axillary crutches comes with a lot of problems such as nerve damage, wrist injury and high energy consumption for the end users. To counter the problems involved many different designs has been proposed till date. All of the design modifications are made for ease of fitting or appearance rather than for improved dynamics. In this paper, a novel flexure based design, capable of ameliorating the crutch locomotion, has ben delineated. The design is made for 3-point gait crutch motion.

Upon conducting user trials and the biomechanical analysis, it was found that the ground reaction forces and the impulse coming on the foot has been reduced significantly by 20% and 18% respectively. The energy expenditure test reveals that the reduction of energy consumption was found out to be around 40%.

Keywords

Assistive device; crutch; energy consumption; flexure; stability.

Introduction

Axillary crutches are used by the disabled since hundreds of years, and many designs had been evolved to counter the problems faces in using a conventional device, but none of them can solve the most of the ergonomic issues accompanied with the traditional crutches. [1] Some of the very common problems associated with the crutches includes loss of polymer tip within few weeks of usage, ergonomically painful, high energy expenditure and stabilization of joints [2]. There is a need for improvement in mobility of the user regarding the kinetic shape and dynamic response of the crutch with the swing or roll over angle [3]. There are crutches with spring assistance for shock absorption and reducing the vertical movement of C.G while swinging but it provides less stability and energy spent in swinging is absorbed by upper limbs only. New designs are aiming at optimizing the kinetic shape of

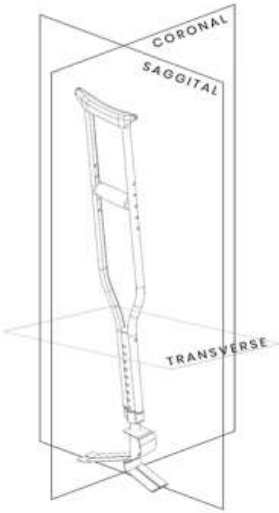

Figure 2: Flexcrutch with the tip showing the planes of the crutch.

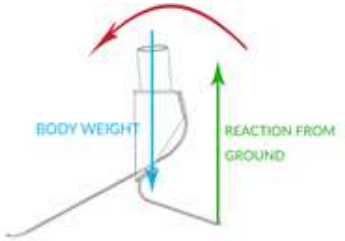

Figure 3: Tip of the Flexcrutch depicting the moment created by ground reaction and the body weight.

the crutch tip but with no shock absorption and stability features.

Design of Flexcrutch

The design of the tip of the Flexcrutch consists of two flexible links (toe and heel flexures). The function of the flexures include absorbing shock during heel strike and aiding to propel forward by releasing the energy stored. The design is inspired from kinetic shape crutch, which converts the bodyweight acting on the crutch to forward moment [4]. The kinetic shape design is based on the geometry of the surface in contact and relative position of applied force and ground reaction force [5]. The shape assures minimum effort to swing about a point on a flat ground. The shape and the deformation due to shock absorption causes the body to move very less against the gravity. This movement reduction along with propulsion leads to reduced energy expenditure. The frontal and back flexures are split longitudinally thereby independently conforming to uneven grounds thus ensuring that it grips any Indian terrain. Additionally the two flexure provide rotational resistance along the crutch shaft improving convenience in holding the crutch. The newer design crutches available in the foreign market absorbs the jarring forces in the upper and lower limb for limited period of swing and do not survive the harsh Indian terrain, but the Flexcrutch ensures maximum absorption throughout the swing.

Together the individual functions add up to the following advantages:

1. Reduction of Energy needed for the Gait motion.
2. Reduce the Jarring forces the body experiences and thereby reducing risk factors in medical side effects.
3. Two point contact provided by the toe and heel ensure stability while walking on flat ground and stairs as well while descending.
4. Increase lifespan of the gripping material in tough terrain.
5. Stability on uneven and tough terrain.

Experimental Validation

To understand the joint motion and muscle fatigue felt by the user while using conventional axillary crutches and Flexcrutch some tests were performed. For performing motion analysis by capturing gait, markers were placed on 5 different subjects using customized protocol. The ground reaction force values were retrieved using force plates which provided the horizontal and vertical reactions of the user during gait. EMG device, strapped on the upper limb, was used for measuring the muscle fatigue and energy expenditure study by using an oxygen consumption-monitoring mask. A comparative study was performed on both healthy individual and patients using crutches. The captured data was processed using MOKKA software. By extracting the markers data, the movement of the markers coordinate was obtained for the complete frames of gait cycle. The relative coordinates and the relative angles were used in modeling the movement of the body in ADAMS.

Conclusion

A set of 5 experiments were conducted. It was found that the impulse and the force coming on the leg have been reduced significantly by 18% and 20% respectively. The energy expenditure test also concluded that there has been 40% reduction in the energy consumption.

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