3D Modelling of a Biomechanical Assistive Prop to Aid Anterior Tibialis in Tibial Muscular dystrophy

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Abstract - Muscular dystrophy (MD) is a gene mutation disorder where the gene fails to interact with proteins in the body. This causes loss of muscles or muscular weakness in certain areas of the human body. Muscular dystrophy is also caused due to other bone injury or muscle injury. People above 35 years of age are most affected by muscular dystrophies. Men are more prone to get affected by muscular dystrophy. Muscular dystrophy is of many types based on the area it affects. Among this, Tibial Muscular Dystrophy (TMD) is the major problem causing muscle weakness in the lower leg. The anterior tibialis muscle of the tibial bone and ankle muscle deteriorates causing inability to walk. People affected with tibial muscular dystrophy could find it difficult to lift their ankle while walking. This may lead to sudden fall or leg tripping. In our project, we focus on developing an automated model of biomechanical brace from a 3D model which helps patients with tibial muscular dystrophy to walk with ease and acts as a strength training assistive device.

Keywords – Muscular Dystrophy , Gene Mutation , Muscular Weakness , Tibial Muscular Dystrophy , Leg Tripping , 3D Model.

I. INTRODUCTION

Muscular dystrophy is a group of conditions that beget progressive weakness and loss of muscle mass. In muscular dystrophy, abnormal genes(mutations) intrude with the product of proteins demanded to form healthy muscle. There are numerous kinds of muscular dystrophy. Symptoms of the most common variety begin in nonage, substantially in boys. Other types do not face until majority. There is no cure for muscular dystrophy. But specifics and remedy can help manage symptoms and decelerate the course of the complaint. The main sign of muscular dystrophy is progressive muscle weakness. Specific signs and symptoms begin at different periods and in different muscle groups, depending on the type of muscular dystrophy.

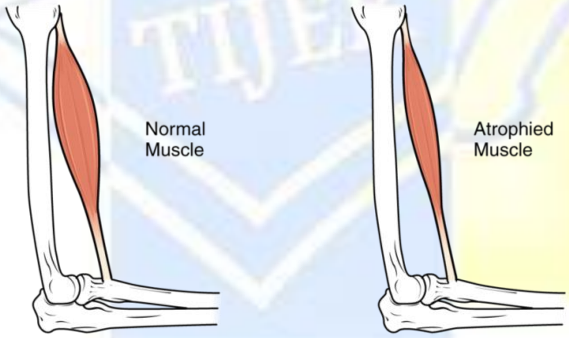

Fig.1 Normal Muscle Vs Atrophy Muscle

II.LITERATURE SURVEY

- **Zhen Yu et al (IEEE Volume 2022)** founded a ergonomic design study of artificial intelligence lower limb-assisted brace for the elderly is a new design standard of lower limb-assisted brace for the elderly with mobility problems. Based on human factors engineering, this study tested and analyzed the advantages and disadvantages of human lower limb motion mechanics, human gait motion law, and existing lower limb assisted brace design cases at home and abroad and concluded that the common external assisted method is less man-machine efficient than the internal assisted method. Therefore, a new brace joint rotation curvature, component parameters, and other key information were designed based on the structure of the medial assistance method. With the help of the engineering and scientific analysis methods in human factors engineering, the designed machines and systems are made more adaptable to the physiological and psychological characteristics of human beings. This is study explores the interaction between humans and machines and the rationality of their mutual integration, which can effectively avoid repetitive strain injuries and other muscle diseases over time for users in the process of assistance and achieve efficiency, health, and safety.

III. METHODOLOGY

In this , we proposed an automated assistive Biomechanical brace to support and treat people affected by tibial muscular dystrophy (TMD). Our proposed model is more precise in design, light weight, easy to use by the patient, and it is battery operated. The major difference from the existing system is that our device does not contain heavy loads. The battery power source is more concise so that the patient does not feel heavy to carry the brace. Our biomechanical brace is designed in a 3D modeling using CATIA V5 software. This device supports the patient who are unable to walk and it acts as a supportive device in improving muscle strength of the patient. Overall, an automated biomechanical assistive brace is comfortable to wear and it is user-friendly.

BASIC STUDIES

GAIT PATTERN OF NORMAL HUMAN LEG

The gait pattern of a normal human leg typically involves a sequence of movements that enable an individual to walk efficiently and effectively. This gait pattern consists of several phases, including:

• **Stance phase:** This is the first phase of the gait cycle and begins when the heel of the foot makes contact with the ground. The stance phase can be further divided into five sub-phases:

1 Heel strike: The moment the heel of the foot makes contact with the ground.
2 Foot flat: The point at which the entire foot is in contact with the ground.
3 Mid stance: The point at which the body weight is directly over the foot.
4 Heel-off: The moment the heel begins to lift off the ground.
5 Toe-off: The moment the toes leave the ground.

• **Swing phase:** This is the second phase of the gait cycle and begins when the foot leaves the ground and swings forward. The swing phase can also be further divided into two sub-phases:

1 Initial swing: The point at which the foot leaves the ground and begins to swing forward.
2 Terminal swing: The point at which the foot is about to make contact with the ground again.

FORCE EXERTED DURING WALKING

The amount of force exerted during walking by a human can vary depending on a variety of factors such as the individual's weight, height, and gait pattern. However, on average, a person exerts a force of approximately 1.5 times their body weight while walking on level ground.

DEGREE OF ANGLE DURING LIFTING HEELS AND TOES

The degree of angle during lifting the heels and toes can vary depending on the individual and the specific movement being performed. However, in general, when lifting the heels off the ground (heel raise), the ankle joint can dorsi flex up to approximately 20 degrees. This means that the angle between the foot and leg can increase by up to 20 degrees as the heel is lifted off the ground. Similarly, when lifting the toes off the ground (toe raise), the ankle joint can plantar flex up to approximately 50 degrees. This means that the angle between the foot and leg can decrease by up to 50 degrees as the toes are lifted off the ground.

WEIGHT BEARING CAPACITY OF HUMAN LEG

The weight bearing capacity of the human leg can vary depending on a variety of factors, such as the individual's weight, height, and overall physical condition. However, on average, the human leg can support a weight of approximately 1.5 to 2 times the individual's body weight.

Human Feet Dimensions

- The average length of human feet is 293.30mm
- The average width of human feet is 117.25mm
- The average width of heel part is 84.02mm
- The above-mentioned data is collected based on the 95th percentile data of Indian human foot dimensions.

3D MODELLING

CATIA is the world's leading design and engineering software for 3D CAD designing. This software is created by Dassault Systems for creating product designs. CATIA is most widely used for 3D design, Product Lifecycle Management (PLM) solutions, Computer-aided engineering solutions, and Computer-aided manufacturing solutions. This software is most used in manufacturing industries and Original Equipment Manufacturers (OEM) for design, analysis and create new product designs. CATIA provides the user the ability to visualise the products with the designs. The features of CATIA includes surface modelling tools as well. The interface in CATIA allows designers to create complex parametric models.

3D modelling is the process of designing three-dimensional representation of images that are created in 3D space. 3D models can mimic the living or animated objects. 3D modelling uses specialised software's by manipulating edges, polygons, and vertices in a simulated 3D space. This can be used in a wide range of applications for simulation, rendering, animation or for manufacturing purposes. Three-dimensional 3D models usually use a collection of points such as lines, triangles, and curved surfaces to represent a physical body. These points are mapped into a 3D grid and then joined together to form such shapes.The core of 3D modelling is to produce a mesh which is best described by the collection of points.

3D printing would be possible only with a 3D model. 3D model is created using a 3D file that provides dimensions for the print.

3D modelling software or programs can be chosen based on the application and industry that you work to create a 3D model. CAD modelling software is the most common software program used for 3D modelling. CAD modelling uses 3D rendering or visualisation techniques for representation of two-dimensional images.

IV. RESULTS

From the above results, a 3D model of Biomechanical Assistive Brace is designed using CATIA software. Different positions of human foot while walking was given in the form of pictorial representation. The positions of walking include Heel rise or ankle rise, toe rise and toe off, heel strike and flat foot positions are clearly shown.

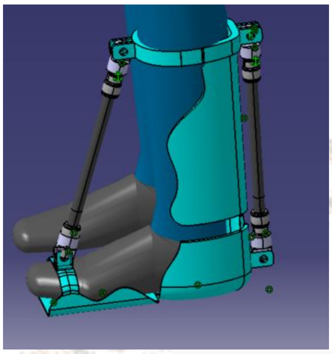

Fig.2 Initial Position – Flat Foot

Fig.3 Heel Rise position 1

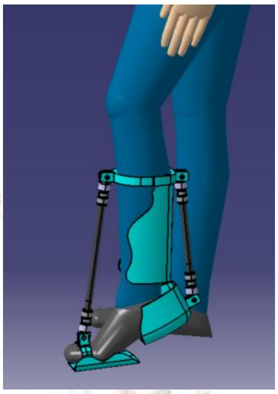

Fig.4 Heel Rise Position 2

Fig.5 Toe Raise Position 1

Fig.6 Toe Raise Position 2

Fig.7 Back to Normal Position

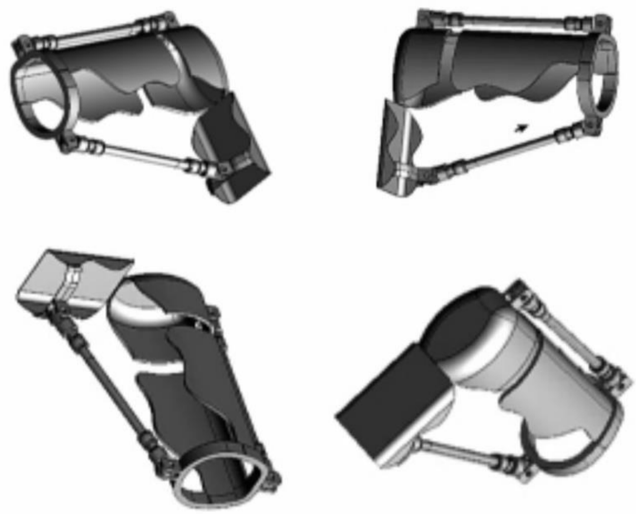

Fig.8 3D model image of designed Brace

V . CONCLUSIONS

Muscular Dystrophy is the major illness which must be taken into considerations. Our idea aims to design a device that could support people with Tibial Muscular Dystrophy. CATIA software is thus used to properly create the 3D modeling of the assistive. The specially created brace will serve as a supportive device and aid in the human normal walking. When this technology is presented to society, it will benefits to those who are disabled due to this TMD. Thus , a low cost and socially beneficial device successfully modeled.

VI . REFERENCES

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