DESIGN AND DEVELOPMENT OF MOBILE AID FOR MUSCULAR DYSTROPHY

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Abstract: A group of muscle diseases resulting in the increasing weakening and the breakdown of skeletal muscles over time is called as muscular dystrophy. The disorders differ in parameters like which muscles are primarily affected, the degree of weakness of bones, how fast they become worse, and when the symptoms for this disorder begin. Many people will become unable to walk eventually. There are more than thirty specific types of muscular dystrophy under nine main categories. The most common type among these is Duchenne muscular dystrophy (DMD). This is caused primarily due to the lack of a protein called Dystrophin and it is found in muscle fibre membrane of our body. Currently, there being no cure for it, some physical, occupational, orthotic intervention (e.g., ankle-foot orthosis), speech, and respiratory therapies may tend in being helpful in terms of management. Being human they also love to travel alone and interested in satisfying their own needs which shows they need to live as a common man/woman than living in a situation where some people always crowd or assist around them in satisfying their needs. So, we decided to break the rules and allow them to move anywhere around their place and use the toilet during a nature call without anyone’s support by integrating the lifting mechanisms and the toilet provision in the wheel chair.

Keywords: Muscular Dystrophy, self-mobility, provisional wheel chair

1. Introduction

Duchenne Muscular Dystrophy (DMD) is a progressive form of muscular dystrophy that occurs primarily in males, though in rare cases may affect females. DMD causes progressive weakness and loss (atrophy) of skeletal and heart muscles. Early signs of DMD may include delayed ability to sit, stand, or walk and difficulties learning to speak. Muscle weakness is usually noticeable by 3 or 4 years of age and begins in the hips, pelvic area, upper legs, and shoulders. The calves may be enlarged. Children with DMD may have an unusual walk and difficulty in running, in climbing stairs, and even getting up from the floor. It may also affect learning and memory, as well as communication and certain social emotional skills. Muscle weakness mostly worsens with age and progresses to the arms, legs and trunk. Most children with DMD use a wheelchair full time by age 13. Heart and respiratory muscle problems begin in the teen years and lead to serious, life threatening complications. DMD is caused by changes (mutations) in the DMD gene. Dystrophin is mainly made in skeletal and heart muscle cells, but a small amount is also made in nerve cells (neurons) in specific parts of the brain. DMD is inherited in an X-linked recessive pattern; however, it may also occur in people who do not have a family history of DMD. While there is no known cure for DMD, there are treatments that can help control symptoms. Due to the advancement of medical treatment, boys with DMD may now live into young adulthood. To overcome this problem of the DMD patients, we have arrived with a multi-provisional wheel chair for their ease and self-reliability.

1.1. Existing aid method and its demerits

At present a wheel chair designed for the patients can drive itself which is equipped with three LiDAR sensors; the wheelchair works much like a self-driving car. In existing model, there are many technologies are being fused to form a comfortable chair and it serves most of the people needs but there are some people who are in need of using the toilet with the help of the wheel chair they travel and if the patient unfortunately falls down or the patient likes to sit on the floor, they need some external help from their guide or family members but
now this wheelchair replaces the human support. Since there are provisions at the back rest for using the toilet and then the lifting mechanism is lacking it feels quite uncomfortable for the patients. Also, the size of the chair is too complicated.

1.2. Proposed methodology
In this method we have designed a chair with a lifting mechanism and a provision at the back rest of the chair so that the patient need not depend on others for moving from one place to another and for using the toilet. Since the patient needs privacy or they need to be independent it can be attained by this project design. The setup can lift the patient who is already sitting on the floor when he/she cannot be able to rise up without any support. So, if patient tries to crawl and sit on the seat of the chair which is elevated from the floor at a minimal distance, it lifts them by a lead screw mechanism which is driven by the DC motor when they switch on. The toilet usage provision is provided at the back rest that they will be able to unfold the back rest which fits right above the western toilet basin. They can move back after using the toilet and fold the back rest as normal.

1.3. Objectives
The motivation of the project is to support the Muscular dystrophic victims and also the physically challenged persons to do their needs with the lifting mechanism integrated wheelchair. The lifting mechanism is used to lift the person from the floor to the normal sitting position. Provisions are provided at the back rest of the seat to use the toilet (western toilet). Movement of the vehicle is made with help of DC motors with supply from battery.

1.4. Literature Review
Muscular dystrophy Canada is a dedicated organisation which reviews the equipment and assistive devices for muscular dystrophic patients. It says that manual wheelchairs are useful for people who have upper body stability and can easily position themselves in the chair. These chairs are light to push and usually collapse to fit easily in a car. Power wheelchairs are appropriate for people who cannot manually propel themselves. They are operated using a joystick (Darryl 2004) or other controlling devices (Keith et al 2004) that can be used by almost any part of the body that you can move. Chair lifts are the motorized chairs have a switch for adjusting the incline and raising the seat. Chair lifts are useful for people with weakened legs who find it difficult to rise from a seated position. The weakened leg can be supported by leg support as referred in literature (Wilhelm 1984) which can be adjusted to desired height. An MIT researcher (Daniela 2017), who designed an autonomous wheel chair which can drive itself, is the latest innovation in the wheel chair technology. Equipped with three LiDAR sensors, the wheelchair works much like a self-driving car. Before the service, someone manually drives it through a given area, and the sensors build a map details how wide the hallways are, where the pillars are, and so on. Once that's set, the user selects where he or she wants to go by click on the map, and the chair gets going, using the sensors to look for "dynamic obstacles" like people walking around, or that chair that wasn't there earlier.

2. System model and Design Calculation
The setup of the chair is not complicated so it can be taken anywhere around the house and the width of the setup is around 550mm and it can be moved through most of the doors. The setup is currently powered by the single mode power supply of 12V and 24 V. Portable power supply can be used but it cost so high. In future it is planned to use the compact power supply like Li-Po battery and the operating weight of the wheel chair at present is around 25Kg and it can be expanded based on the motor capacity. In also planned to design a required motor with compact and powerful weight lifting capacity and high torque. The components that are essential to build the wheel chair are shown in Table 1.1.
The CAD model shown in Figure 2.2 was created using the Creo3.0 software.

| Sl. No | Description                                      | Cost in Rs. |
|-------|--------------------------------------------------|-------------|
| 1     | Lead screw of 1 inch diameter                    | 1300.00     |
| 2     | DC motor 12V (Wheel motor – 2 no’s)              | 3200.00     |
| 3     | Hollow Square Rod, Hand support                  | 1850.00     |
| 4     | DC motor 24V (Lifting motor)                     | 2300.00     |
| 5     | Single mode power supply 24V & 12 V              | 1850.00     |
| 6     | **TOTAL**                                        | **10500.00**|

Table 1.1 List of components used

2.1. **Design Specification**

**Lifting Motor**
- **Type**: DC series motor
- **Operating Current**: 5A
- **Operating Voltage**: 24V
- **Torque**: 500 kg cm
- **Revolutions per minute**: 60
Wheel Motor
Type : DC series motor
Operating Current : 5A
Operating Voltage : 12V
Torque : 60 kg cm
Revolutions per minute : 30

Lead Screw
Diameter : 1 inch
Length : 0.45 m
Thread type : Square thread

Spur Gear
Gear material : Cast Iron
Teeth count (driving gear) : 25
Teeth count (driven gear) : 50

Wheel
Material : Nylon
Diameter : 0.1 m

Hollow Square Bar
Cross sectional area : 0.625 m²
Material : Mild Steel

2.2. Design Calculation
Required torque calculation for the person of 40 kg weight
Setup Weight : 9.85 kg
Person weight : 40 kg
Total weight : 49.85 kg
Acc. due to gravity : 9.81 m/s²
Sliding Distance : 0.2 m
Force = Mass x Acceleration
= 49.85 x 9.81
Force = 489.028 N
Torque = Force x Distance
= 489.028 x 0.2
= 97.80 Nm

Here, the theoretical torque required for lifting the person of 40 kg weight is 97.80 Nm. But here, a DC motor of 50 Nm torque only is used which is insufficient to carry the stipulated load and can carry only half of its weight (i.e.) 20 kg.
2.3. **Torque calculation to run the lead screw**

- Mass of the lead screw, M : 2.5 kg
- Diameter of the lead screw, D : 0.025 m
- Frequency, \( \mu_f \) : 2.23 Hz
- Length of the lead screw, L : 0.50 m
- Acc. due to gravity : 9.81 m/s\(^2\)

Force = Mass x Acceleration  
= 2.5 x 9.81  
= 54.525 N

Torque, \( T \) = \( F \times D \frac{[3.14 \times D - \mu_f \times L]}{2 \times [L + \mu_f \times 3.14 \times D]} \)  
= 24.525 x 0.025 x \( [3.14 x 0.025 - 2.23 x 0.50] / 2 x [0.45 - 2.23 x 3.1 x 0.025] \)  
= 0.5601 / 1.2562  
Torque, \( T \) = 0.45 Nm

2.4. **Speed Reduction Calculation**

Angular velocity to linear velocity is given by,  
\[ V = r \times w; \]

Where,  
- \( r \) = Radius in meter  
- \( w \) = Angular velocity in rad/s

The RPM to linear velocity is given by,  
\[ \text{Linear Velocity} = r \times \text{RPM} \times 0.10472 \]

Radius of driving gear = 0.05 m  
Revolutions per minute = 60

Linear Velocity = 0.05 x 60 x 0.10472  
Linear Velocity = 0.314 m/s

Velocity Ratio \( = \) \( \frac{\text{Teeth count (driven gear)}}{\text{Teeth count (driver gear)}} \)

Teeth count (driven gear) = 50  
Teeth count (driver gear) = 25  
Velocity Ratio = 50/25  
Velocity Ratio = 2

Output speed = \( \frac{\text{Input Speed}}{\text{Velocity Ratio}} \)  
= 0.314/2
Output Speed \[= 0.157 \text{ m/s}\]

3. Working of the project

If the patient is sitting on the floor and is willing to sit on the wheelchair as shown in Figure 4.1 either normally or in case he/she wants to use the toilet, they can easily crawl backward and have to sit on the wheelchair, the chair will be found initially in a low position at a height of around 10cm as shown in Figure 4.2.

![Figure 4.1 Photographic view of the project](image1)

![Figure 4.2 Initial Position of the wheelchair](image2)

After the patient gets seated in the chair, they can use the DPDT switch for lifting them up which is positioned on the column below the right-side hand rest as shown in Figure 4.3. The vehicle motion can be controlled by two DPDT switches located on both the left- and right-hand rests. Turns can be taken either by moving forward the motor on the right and moving back the motor on the left side and vice versa. A
soft turn can be made by arresting one motor and running the other. The lead screw mechanisms and motors are shown in Figure 4.5

Now if the patient likes to use the toilet, first they need to unfold the back rest of the chair at the time they approached the western toilet and the wheelchair seat cushioning system Denny and Chris (1997) are referred. After unfolding, the back rest is made to get engaged with the toilet basin and they can slowly move back to sit on the toilet basin (western style) and after using the toilet they can move forward slowly and then the back seat is folded and locked up as the backrest again. They can again get down to the floor by reversing the lifting motor using the DPDT switch.

Since, the wheelchair will be in two positions. One is for making the patient to sit on the Wheelchair and the other is the final position as shown in Figure 4.4 looks like a normal seating position and the wheelchair mid position is shown in Figure 4.3. So, the patient has the feasibility to lift the chair to any height.
4. Conclusion
Since there is no cure for Muscular Dystrophy disease and they are currently left in the hands of physical therapy, corrective surgery and with steroids. The disease affected patients are always want to be independent in satisfying their needs without anyone’s support because most of the times family members are always surrounded to help. So, this project will satisfy their thirst of waking up themselves and using up the toilet without support of any people and make them lead normal life as every human lives. A brushless DC motor of high torque and efficiency must be employed for precise lifting. A battery backup must be made portal by employing a battery with high operating time with 5 Ampere of operating current. Shifting of patient to the toilet is to be made enough easy with some mechanisms.

5. References
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