TYL 4: RWTD

Electrical & Mechanical Engineering

Robotic Walking Training Device

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Abstract

Partial paralysis caused by spinal cord injury (SCI) or stroke are two of the most prevalent forms of physical disability. It is estimated between 232,000 to 316,000 people have a SCI, and approximately 795,000 people have a new or recurrent stroke annually. More than 50% of stroke victims have difficulty walking, and greater than 90% of SCI patients lose sensory and motor control of their lower limbs. The goal of the Robotic Walking Training device is to build and optimize a training device that can accurately recreate the motion of a gait path. It will also incorporate the use of a Functional Electrical Stimulation to allow for more efficient and effective retraining of neural pathways. To recreate the gait paths, data was collected of a natural walking gait path. The use of FES will be used in sync with the gait cycle to stimulate the muscle at the appropriate timing.

Background

Due to patients losing their sensory and motor control when they have injuries, such as SCI or strokes. To help patients who have these disabilities regain the function of walking unassisted, gait rehabilitation is performed.

To also aid in rehabilitation FES device can also be used. A FES is a device that applies small electrical pulses to the muscles in the lower extremities that are affected by injuries to restore or improve muscular function. By applying these small electrical pulses, the pathways that have been disrupted or broken can be re-written allowing for the patient to use their muscles as they did before the injury occurred.

Specifications and Design Constraints

Specifications

- Reproduce natural gait motion path of knee and ankle.
- Adjustable for varying leg lengths up to 6’4” patients.
- Electro-stimulate thigh muscle in time with the walking motion.
- Able to hold various body types, up to 300 lbs.

Design Constraints

- $2000 budget.
- Fulfill the needs and satisfy the customer.
- Ensure that the required resources, such as tools, materials and parts, are available to construct the RWTD.
- Simulations to prove that specifications are met using the designed system

Design and Approach

The RWTD will have 4 main components as seen in Figure 1.

1. Scissor Lift - Provides the vertical motion necessary to raise the patient
2. Arm Supports - Adjustable for each patient and fold down allowing for the patient to get in the device with ease
3. Leg Assembly - Provides the necessary motion to accurately recreate the gait motion path, using 6 motors, one at each joint: hip, knee and ankle. The leg assembly is adjustable for patients of different heights
4. FES System - Will be used in conjunction with the motion of the legs. The thigh muscle will be stimulated in time with the motion to optimize rehabilitation

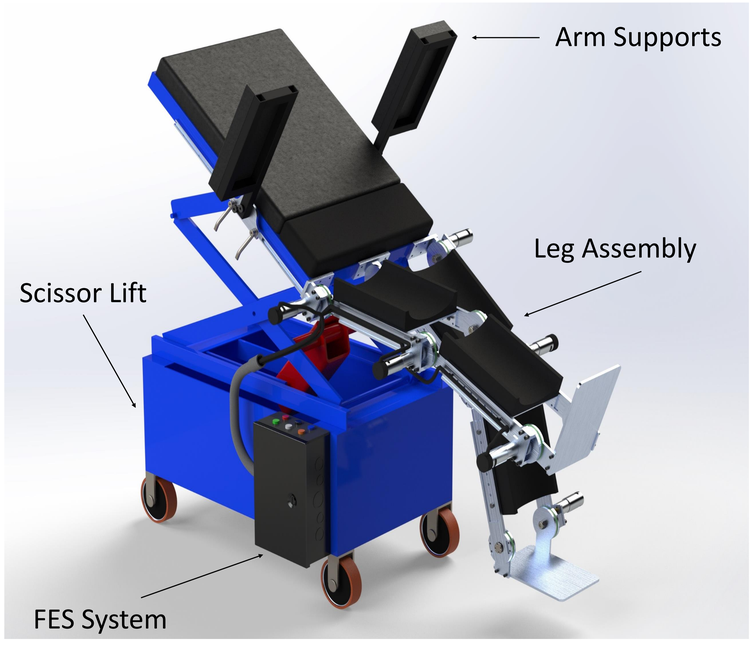

Figure 1. RWTD showing the 4 main components of the project.

Results and Discussion

The selected concept was the motor driven linkages. Utilizing 6 motors, one at each joint, an accurate gait motion path can be generated. The linkages will be constructed from 6061 Aluminum since it is durable and relatively easy to machine. The pivot pin will be manufactured out of cold-rolled steel since it will need to endure high torque being applied. Lastly, the motors were chosen due to the amount of torque that will need to be applied at both hip motors.

The pulse chosen for the FES was high-voltage pulsed stimulation. This pulse was chosen for its indicators in patients. These include but are not limited to; reeducation of peripheral nerves, delay of denervation, and disuse atrophy by stimulating muscle contractions and restoring range motion. The FES will use 0-500 mA for a treatment duration of 15-30 minutes to aid in the rehabilitation process

Upgrades Made to the System

Upgrades made from the 2nd Generation

- Leg Assembly components machined from Aluminum 6061
- Joint Pins machined from Cold-Rolled 1020 Steel
- Redesigned base fabricated from A36 Steel Plate
- Adjustable arm supports for patient stability and comfort
- Memory foam padding for patient comfort
- Linear actuator that allows smooth transition to upright position
- Planetary gear driven DC motors for each leg joint for customizing degree of motion

Conclusion

The goal for this project is to design and optimize a device to assist patients in recreating a natural walking gait while simultaneously applying stimulation with a Functional Electronic Stimulator in order to more efficiently and effectively retrain the neural pathways. The chosen design utilizes 6 motors, located at each joint, to recreate the gait motion path through a programmed pathway. An electrode of the FES will be attached to the thigh muscle to stimulate the muscle while a step is being taken, thus retraining the neural pathways.

Analysis was completed to determine the materials needed to construct the device. Analysis was also performed to determine the stability of the device when in use, the maximum amount of torque and the shearing on the pivot pin in the hip joint.

Lastly, simulations were performed to prove that the design choice for the project would meet specifications if the manufacturing could be completed. Simulations proved that the leg assembly would move in correct path without any interference. The scissor lift could be raised and lowered without failing. The arm supports would not fail during the use of the device.

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