Pediatric Orthopedic Lower Extremity Gait Trainer
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Project Objective
The purpose of this project is to design, build, and test a pediatric gait training apparatus that will provide a variety of rehabilitation functions, such as:

- Correction of lower extremity deformities
- Provide stability to lower extremities
- Provide a mechanism of motion assistance

The Orthopedic brace is designed as a rehabilitative device that can not only correct deformities of gait, but also provides a mechanism of motion assistance and resistance that retrains weakened muscles in the lower extremities. The proposed design was based on a model that can be worn everyday to increase effectiveness of rehabilitation.

Proposed Design

**Brace**
This is a four segment brace design; each segment is held by a joint system that mimics the same range of motion that the body undergoes during a normal gait cycle. In addition, the four segments are adjustable so that the brace grows as the pediatric patient grows.

**Motion Assistance**
To facilitate muscle growth, a system of motion assistance and resistance will be implemented. Two 180 degree Torsional springs will be attached at each knee; these will mimic the quadriceps. Tension bands will be attached to the back of the brace; these will act like the hamstrings. Together, these mechanisms provide resistance to assist in building muscle.

Materials and Methods

**Prototype Construction Process**

**Step 1:** Take patient measurements such as weight, height, and any physical abnormalities. (such as flat foot, high arch, scoliosis, etc).

**Step 2:** Cast the patient’s lower extremities for molding.

**Step 3:** Create a mold from the patient’s cast.

**Step 4:** Heat, drop, and vacuum plastic over the patient’s mold.

**Step 5:** Machine the hip and knee joints.

**Step 6:** Align the hip, knee, and ankle joints with the patient’s natural axis of motion.

**Step 7:** Assemble the brace.

**Step 8:** Attach the mechanisms for motion assistance (torsion springs and tension bands).

**Step 9:** Make adjustments to brace, springs, and tension bands until patient can move naturally and brace is comfortable.

Mechanical and F-Scan Results

**Mechanical Testing of the Knee Joints**

- **Fatigue Failure Test**
  - Function: Sine Wave
  - Frequency: 2Hz
  - Cycle: 30,000 cycles
  - Cyclic loading: 1000 N

- **Axial Failure Test**
  - Function: Ramp
  - Axial load set up: Compression
  - Run rate: 50N/s

**F-Scan Analysis of Patient Gait**

- **Normal Gait**
- **Brace**
- **Brace and Extensors**
- **Brace, Extensors and Flexors**

**Scan Results**

- The knee joint maintained its integrity over 30,000 cycles at 2Hz frequency with the repeated load of 1000N
- The maximum compressive force the knee joint can achieve is up to 4857 N with an actual maximum displacement about 1.14 mm before it failed

Patient Comfort Test

The test subject wore the prototype for a total of eight hours and was able to give feedback on the device’s performance, comfort level, ease of use, and aesthetics.

The test subject commented that she could indeed feel the effect that the springs were having on the overall motion of the device.

The subject further stated that there was a significant difference between wearing the device without the tension bands and wearing the device with tension bands.

Conclusion

The prototype was successfully built based on the criteria of proposed design.

The mechanical test proves the feasibility of the knee joint design.

The mechanism of motion assistance was noticed working according to the test subject’s feedback.

The total cost to construct the prototype was approximately $600.

Future Work

- Scale for pediatric size - the next step is testing the device on a pediatric patient.
- Improve aesthetics of design - modify the manufacturing process so that metal has smooth finish and plastic has a smooth, flawless appearance. Design could use some slimming down.
- CNC automation of joint manufacturing - make a program that can automate the manufacturing of joints
- Collect Anthropometric data - collect data so that general brace sizes can be manufactured

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