Gait Retraining
Post Total Hip Arthroplasty

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What is a Total Hip Arthroplasty[3]

- Consists of removing and replacing damaged portions of the hip
- Causes
  - Osteoarthritis
  - Rheumatoid Arthritis
  - Osteonecrosis
- Benefits
  - Reduced pain
  - Increased stability
  - Increased mobility

[1] Total Hip Replacement
Relevance

Procedure Codes for All Hip Procedures 2012-2017 (N=443,219) [2]

- Hip Resurfacing (n=2,039) 0.5%
- Others (n=3,945) 0.9%
- Partial Hip Replacement/Hemiarthroplasty (n=31,336) 7.1%
- Hip Revision (n=54,959) 12.4%
- Total Hip Replacement (n=350,941) 79.2%

Percent of All Hip Arthroplasty Procedures

Problem

Gait symmetry is not addressed → Leads to degradation of the joint replacement → A revision is needed

Previous Investigations: Gait After Total Hip Arthroplasty

- **6 months**
  - Gait alterations persisted even with different surgery methods [9]

- **10 Months**
  - Gait alterations and compensations still exist with gait mechanics [4]

- **10 years**
  - Across all ages gait did not return to normal [5]

Previous Investigations: Gait After Total Hip Arthroplasty

Gait Measurements ~10 months post-op [4]

Previous Investigations: Gait After Total Hip Arthroplasty

Gait Measurements 10 years post-op[5]

Previous Investigations: Ways to Alter Gait

Wearable Sensors  [12][13][14]

Biofeedback and Real Time Gait Retraining  [7][10][11][15]
Previous Investigations: Wearable Sensors

• Used to for knee osteoarthrosis, Parkinson’s disease, and post-stroke patients
• Most widely used sensors
  • Accelerometer
  • Gyroscope
  • Goniometers
• Mainly used to monitor healing progress in rehabilitation
• Used to study gait kinematics and kinetics
Previous Investigations: Biofeedback

- **Biofeedback**: The use of sensors and electronic equipment to provide a patient with a stimulus to retrain physiological events
- Used to alter asymmetric limb loading after Hip Arthroplasty
- Used to improve ROM and flexor muscles in children with cerebral palsy
- Used to increase step length of paretic limbs and correcting step-length asymmetry
Our Study

Wearable Sensors + Biofeedback Vibration Motor = Better Rehabilitation
Wearable Sensors

- Inertial Measurement Unit
- Flexible Electrogoniometer
- Force Sensor
Inertial Measurement Unit [14]

- Inertial Measurement Units (IMUs) are self-contained, wearable systems that measure linear and angular motion.
- They also measure segment orientation, joint velocity, and joint angles.
- Consist of gyroscopes and accelerometers used to detect gait events.
  - Gyroscope: angular velocity sensor that uses high-pass filtering
  - Accelerometer: inertial sensor that uses low-pass filtering

Flexible Electrogoniometer

- Measures range of motion around a specific joint as an individual moves.
- Made up of two arms positioned at specific points on the body connected by a protective spring aligned at the joint to be measured.
- Operated by measuring the change in the physical signal resulting from the angular change at the center of the device.
Our Study:

- Focus on Hip Range of Motion and Extension/Flexion for Kinematics
- Easy to measure with an electrogoniometer and inertial measurement unit
- Directly caused by gait adaptations
Force Sensor

- Force sensors can be integrated into footwear to measure ground reaction forces during gait.
- Provide kinetic measurements
Our Study:

- **Force Sensors for Kinetics**
  - Based on the orientations of all the leg segments obtained from the gait kinematics, the kinetic analysis can be performed to obtain additional kinetic information in the form of joint moments and joint powers of the lower extremities.
Benefits of Wearable Sensors

- Lightweight
- Portable
- Easily Applied
- Adaptable
- Flexible
- Low power consumption
- Useful in the assessment and evaluation of repetitive movements.
Our Study:

Biofeedback

• Using a vibration motor to provide stimulus to adjust gait mechanism
Timeline

3x a week for 6 weeks integrating with Physical Therapy

At home use for additional 6 weeks after Physical Therapy

Check up at 12 weeks post-op to see if additional use is needed
Study Breakdown

Specific Aims

1. Retrain hip kinematics focusing on range of motion and extension/flexion

2. Retrain hip kinetics using GRF sensors

Methods

- Sensors
- Biofeedback
References


References


Questions?