Robotics & Technology to Facilitate Extremity Movement

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choa.org/robotictherapy
Objectives

• The purpose of this session is to enable the learner to

  – Understand the different types of Advanced Technology and Robotic devices that can be used when managing children with Cerebral Palsy
  – Recognize available advanced technology and robotic devices used in children with Cerebral Palsy to assist with movement
  – Identify how outcomes, insurance and episodes of care are incorporated into clinical practice
Rationale

• Concept of Neuroplasticity and Motor learning
  – Influenced by intensity, repetition and frequency
  – Looking at reorganization of cerebral cortices and spared neural pathways

• Task oriented repetitive movements can improve strength and movement coordination
Pediatric versus adult therapy

- The developmental trajectory
- Changes in center of gravity and body mass
- Muscle control
- Strength
- Musculoskeletal
  - Spasticity
  - Contracture
  - Joint and bone deformities
Current types of technology and robotics used at Children’s

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A systematic review of interventions for children with cerebral palsy: state of the evidence

- Of 64 CP interventions, 24% are proven to be effective (Green)
- 70% have uncertain effects (Yellow) and routine outcome measures needed to confirm effectiveness
- 6% are proven to be ineffective (Red)

- Current interventions used in robotics and technology
  - Biofeedback: Yellow
  - Context focused therapy: Green
  - Electrical stimulation: Yellow
  - Goal directed training: Yellow
  - Body weight support: Yellow
  - Whole body vibration: Yellow
    - Novak I et al 2013
Effects of robotic therapy on upper extremity function in children with cerebral palsy: A systemic review

• Objective
  - To systemically examine the effects of robotic therapy on upper extremity function in children.

• Method
  – A systemic literature search was conducted up to July 2013.
  – Studies of children with CP, using robotic therapy and measures of UE were included.

• Results
  – Nine articles using 3 different robotic systems were included.
  – Robotic therapy showed potential effects as all studies reported at least one positive outcome.
  – A moderate effect in improving reaching duration, smoothness, or decreased muscle tone, and a small to large effect in standardized clinical assessment (Fugl-Meyer).

• Conclusion
  – The review confirms the potential for robotic therapy to improve UE function in children with CP.

• Chen Y, Howard A 2016
Goals for episode of care

• Ultimate goals are to work on each patient’s individual level of function
  – One goal may be holding head up long enough during feeding
  – Different goal may be endurance training for a race coming up

• Episodes should incorporate current goals of patient and family

• These goals may change over the course of development/age
  – As patient matures are they able to work on more self care
  – As patient gains interest in a specific activity we can incorporate that skill set and endurance needed into plan of care

• It is important to continue to discuss with your doctor timing of intensive therapy
  – If getting injections or muscle lengthening is it an opportune time to train muscles more intensively or with feedback?
Goals for episode of care

Upper extremity
- Increased ability to reach
  • Reach items off shelf or in closet
  • Overhead reach for hair washing
  • iPad communication/gaming
- Increased functional use of trunk
  • Rolling
  • Forward/side reaching
- Increased functional use of hand for following
  • Feeding
  • Holding/applying deodorant
  • Opening containers
  • Wiping face/Bathing/Dressing
  • Don/doff glasses
  • Grasp and release objects

Lower extremity
- Increased ability to stand independently
  • Lower body dressing
  • Independence with transfers
- Increased functional use of lower extremities
  • Stair climbing/ambulation
  • Biking on tricycle
- Increased strength, endurance and coordination
  • Keep up with peers on playground
  • Sit and hold head up to enjoy family time at dinner table or TV
  • Participate in regular or adaptive sports
Functional electrical stimulation
FES UE/LE cycles - function

• Reduction of tone and muscle spasms
• Prevention or retardation of disuse atrophy (strengthening)
• Increasing local blood circulation (cardiovascular endurance)

• Neuroplasticity and motor planning
• Improving sensorimotor input and sensory awareness
• Maintain and increase range of motion
Does therapeutic electrical stimulation improve function in children with disabilities? A comprehensive literature review

• Objective
  – A search of the literature to discuss clinical use and types of electrical stimulation. Look at potential benefits to help with functional impairments in pediatrics.

• Method
  – 37 articles from 2003-2013 with keyword “electrical stimulation”. Articles only with participants < 18 years of age. Reviews, letters, commentaries, abstracts or articles where NMES was not primary intervention were excluded.

• Results
  – Literature suggests that improvements in impairments may occur with the use of electrical stimulation.

• Conclusions
  – NMES and FES appear to be safe and useable in the pediatric population.
  – It is important that providers understand the indications and parameters to use stimulation effectively.

FES end effector device
FES cycle for gross patterning
FES cycle for gross patterning
Functional portable stimulation device for leg

- Ankle strengthening
- Intrinsic feedback
- Assist with a more natural gait pattern
- Improve proprioception
- Reduce atrophy
- Improve range of motion
- Increase local blood circulation
Functional stimulation for specific skills

- Can isolate individual muscle groups to work on specific function
  - Knee control in standing
  - Side stepping
  - Step ups
  - Bridging
  - Kneeling
  - Sit ups
FES for upper extremity movement

- Passive, active assist, or active biking system
- Computerized gaming system
- Can work on trunk control in conjunction with cycling
Functional portable stimulation device for hand

- A wireless device
  - delivers low-level electrical stimulation
- Activates the nerves that control the muscles in the hand and forearm
- Supports wrist in a functioning position
  - Allowing the fingers and thumb to move efficiently
  - reaching, grasping and pinching
Results
Functional stimulation for specific skills

- Use of devices with built in programs for performing task-specific activities paired with functional electrical stimulation
- Specific timing of each individual muscle involved in the pattern
- Program examples
  - Handwriting
  - Brushing hair
  - Brushing teeth
  - Grasp and release patterns
Body weight support training
Body weight support training

- Can use with varying needs of assistance levels
- Can work on functional transitions
  - Half kneeling, pull to stand, transfers
- Stair climbing
- Uneven terrain/obstacle course
- Decreased reliance on upper extremity support

- Error full learning
- Dynamic sitting/standing balance
Ambulación con y sin soporte de peso corporal
Body weight support with obstacles
Upper extremity body weight support

• Biofeedback with video gaming
• Active assistive, active or resistive arm movement
• Option for unweighting of upper extremity
• Can perform unilaterally or bilaterally
• Can perform in sitting or standing
• Can perform facing towards or away from screen
• Assist with enhancing arm functionality for independence with daily tasks
Before use of body weight support
Body weight support for upper extremity
Carry over after body weight support
Use of body weight support
External robotic systems
External robotic systems

A motorized computer-controlled robot that generates passive, active assistive or active guided, symmetrical trajectories that are consistent with a normal physiological gait or upper extremity reach/grasp/release pattern

**UE device examples**
- Armeo spring - Hocoma
- Amadeo - Tyromotion

**LE device examples**
- Ekso
- Indego
- Lokomat - Hocoma
- ReWalk
Function and use

- Robots allow for increased repetition of specific movement patterns
- Allow for guided real time feedback
- Limited by speed of movement
  - Decreased speed so may be good to start with then follow up with another device to increase speed
- Opportunities for learning through adapting to movement
- Strengthening through resistance
Walking overground preparing for exoskeleton

With Braces

Without Braces
Ambulation in exoskeleton
Exoskeleton continued
Robotic external device for patterning

- Gross hand or individual finger movement
- Can isolate thumb movement
- Utilizes biofeedback via gaming for motivation
- Can perform multiple repetitions in desired movement pattern
Additional devices
Vibration devices

- Side-alternating vibration platform for intense muscle training
- Increase proprioception
- Improve strength
- Decrease tone
- Increase motor activation
- Assist with body position awareness
- Assist with environmental awareness
Vibration in for shoulder strength
Vibration in standing
Vibration for hand to decrease tone/strengthen
Video gaming feedback

• Sensorgriff measures
  – cylinder grip, pincer grip and range of motion
  – Integrated position sensors to measure range of motions

• Multi-ball trains
  – Pronation/supination
  – Wrist flexion/extension

• Multi-board use
  – Repetitive training of individual or several joints
Fine motor tasks with feedback
Interactive feedback
Gaming feedback continued
Interactive gaming in standing
Interactive therapy
In summary
Translating to results

• Reality of healthcare
  – Outcomes
    • Tracking objective data over course of episode
    • How do therapeutic tasks translate to function
  – Insurance
    • What requirements do the policies have
    • Is there secondary insurance
    • Are there grants available to provide assistance when insurance is exhausted
  – Episodes of care
    • Frequency and duration of care: 2-3x/week for 12 weeks or 2 week intensive
    • After episode of care, break may be warranted to “allow practice and generalization”
  – Goal setting
    • Measurable and functional
    • Meaningful
Insurance/payment options

• **Private**
  – Plans based on medical necessity
  – Hard max number of visits
  – Shared visits

• **Medicaid**
  – Pre authorization
  – Chronic versus acute
  – CMO versus traditional Medicaid

• **Grants**
  – Fundraisers
  – Organizations

• **Self-Pay**
Putting it all together through experience and research

- Many different pieces of advanced technology or robotic equipment
- There is not one single device that produces all results
- Increase duration, intensity and dosage makes a difference
- Task-specific/functional task training is essential to motor learning
- Suggests that robot-assisted therapy may lead to functional improvements beyond what is gained with traditional therapy
- Active participation versus passive leads to superior results
Where do we go from here

• Continue to identify research opportunities to study the technology available
• Continue to work with patients and families on specific goals during episodes that are functional and measurable
• Continue to identify ways to incorporate repetitions and intensity into daily activities/extra-curricular activities after episode is completed
  – This is the best method for carry over and maintenance of skills
Questions

• Thank you!
References


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- All videos and pictures of patients obtained with parental consent