Tech4POD

TECHNOLOGIES FOR PEDIATRIC ORTHOPAEDIC DISABILITIES
Marquette University Rehabilitation Engineering Research Center

Rehabilitation Engineering Research Center on Technologies for Children with Orthopaedic Disabilities

Program Director: Gerald F. Harris, Ph.D., P.E

Co-Director: Li-Qun Zhang, Ph.D.

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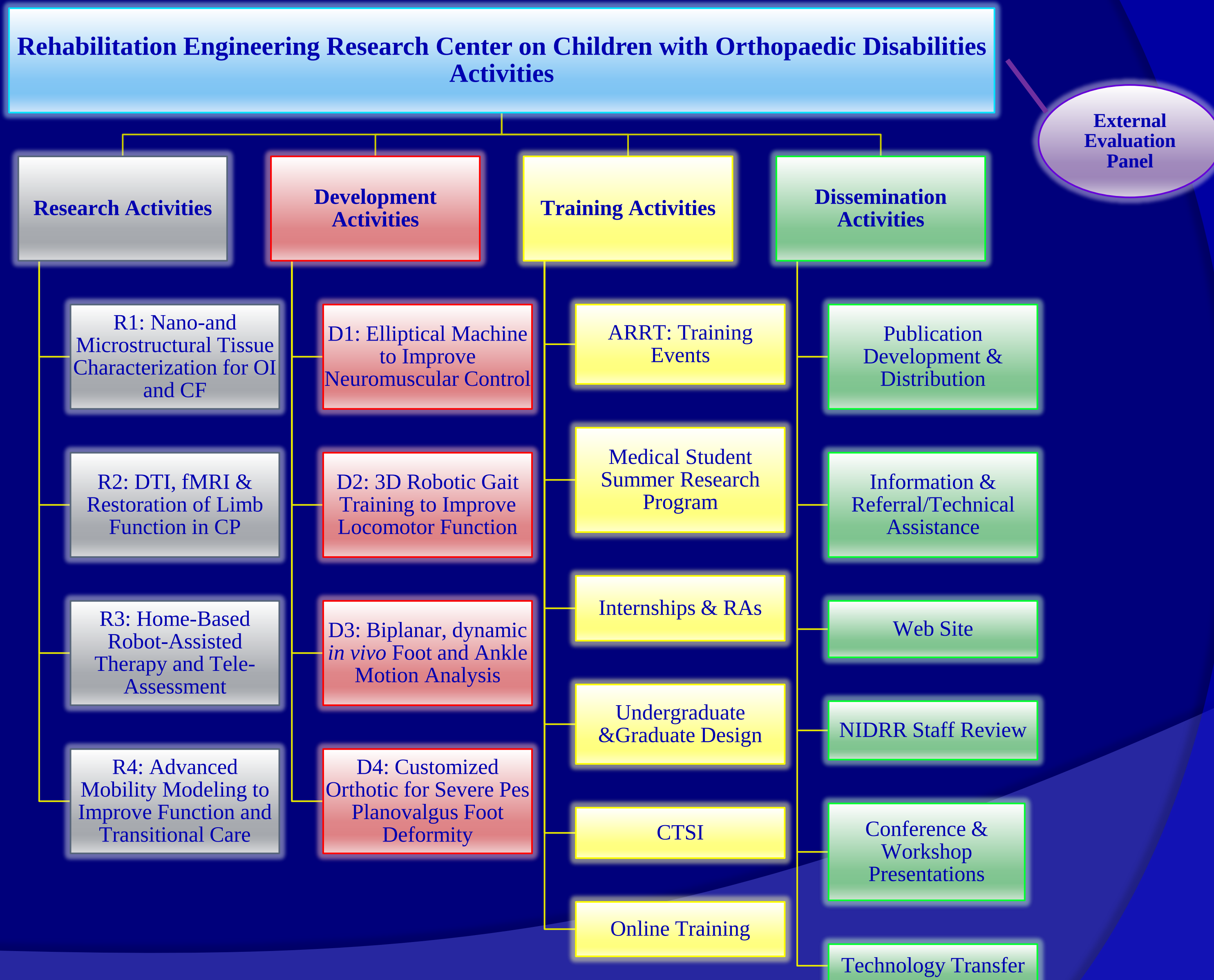
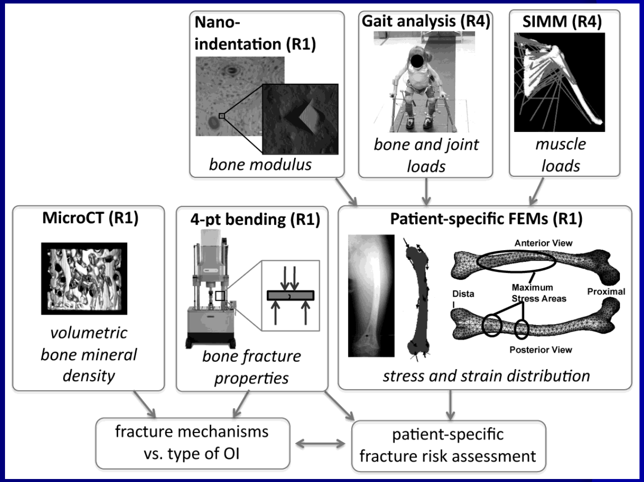

Rehabilitation Engineering Research Center on Children with Orthopaedic Disabilities Activities
External Evaluation Panel
Research Activities
Development Activities
Training Activities
Dissemination Activities
R1: Nano-and Microstructural Tissue Characterization for OI and CF
R2: DTI, fMRI & Restoration of Limb Function in CP
R3: Home-Based Robot-Assisted Therapy and Tele-Assessment
R4: Advanced Mobility Modeling to Improve Function and Transitional Care
D1: Elliptical Machine to Improve Neuromuscular Control
D2: 3D Robotic Gait Training to Improve Locomotor Function
D3: Biplanar, dynamic *in vivo* Foot and Ankle Motion Analysis
D4: Customized Orthotic for Severe Pes Planovalgus Foot Deformity
ARRT: Training Events
Medical Student Summer Research Program
Internships & RAs
Undergraduate &Graduate Design
CTSI
Online Training
Publication Development & Distribution
Information & Referral/Technical Assistance
Web Site
NIDRR Staff Review
Conference & Workshop Presentations
Technology Transfer

Expected Impact on Target Population

- Primarily children with cerebral palsy (CP), clubfoot (CF), osteogenesis imperfecta (OI), myelomeningocele (MM) and spinal cord injury (SCI)
- Children with other chronic conditions that affect manipulation and mobility may also be affected by the study findings
- Our aim is to have a national impact on care and treatment through improved technologies
  - Specific R (research) findings
  - D (development) contributions and commercialization
  - Evolution of improved assessment and evidence-based evaluation tools

R1: Nano- and Microstructural Tissue Characterization for Improved Care of Children with Osteogenesis Imperfecta and Severe Clubfoot Deformity (Focus Topic)

- Co-PI's
  - Gerald Harris, Ph.D., P.E.
  - Jeffrey Toth, Ph.D.



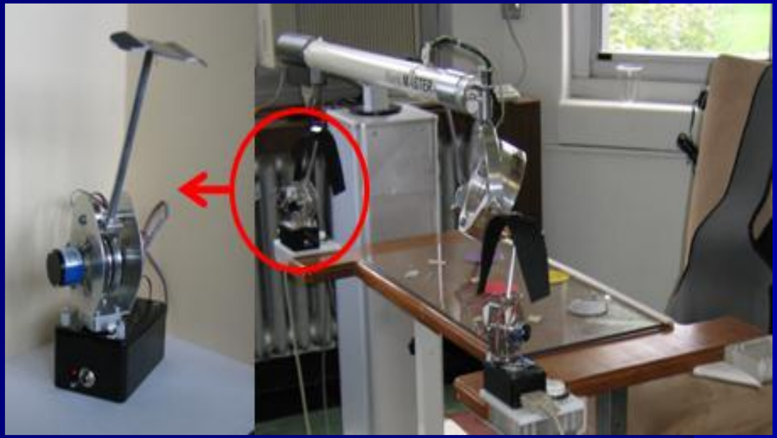
- Patient populations
  - Osteogenesis Imperfecta (OI): 45
  - Clubfoot (CF): 12

R1 Hypotheses

1. Patient-specific FEMs can be used to predict bone fracture and deformation (strain) patterns in children with OI
2. Fiber orientation, distribution and mechanical behavior of MFMT (medial fibrotic mass tissue) in CF are predictive of longer-term maintenance of restoration
3. FEMs incorporating hard and soft tissue can be used to develop more optimized conservative treatment for the prevention of recurrence in pediatric CF

R2: Diffusion Tensor Imaging and Restoration of Upper and Lower Limb Function in Children with Cerebral Palsy

- Co-PI's
  - Michelle J. Johnson, Ph.D.
  - Brian D. Schmit, Ph.D.
- Patient population
  - Cerebral Palsy (CP): 40
- Overall goal
  - Quantitatively assess brain white matter structure (DTI and fMRI) before and after combined intervention strategies of surgery plus novel robot therapies

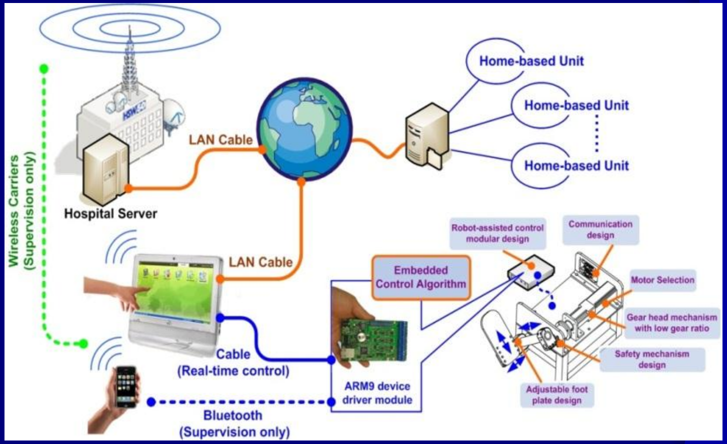


R2 Hypotheses

1. The motor adaptations to hamstring lengthening and wrist tendon transfers depend on the underlying structure of the brain white matter tracts, (e.g. corticospinal tracts and thalamic radiations) as measured using DTI
2. fMRI measures of brain plasticity will reflect the extent of motor adaptation to hamstring lengthening and wrist tendon transfers
3. Robotic interventions will accelerate fMRI changes as well as subsequent recovery of motor function

R3: Home-Based Tele-Assisted Robotic Rehabilitation of Joint Impairments in Children with Cerebral Palsy

- Co-PI's
  - Li-Qun Zhang, Ph.D.
  - Yupeng Ren, M.S.
- Patient population
  - Cerebral Palsy (CP): 48



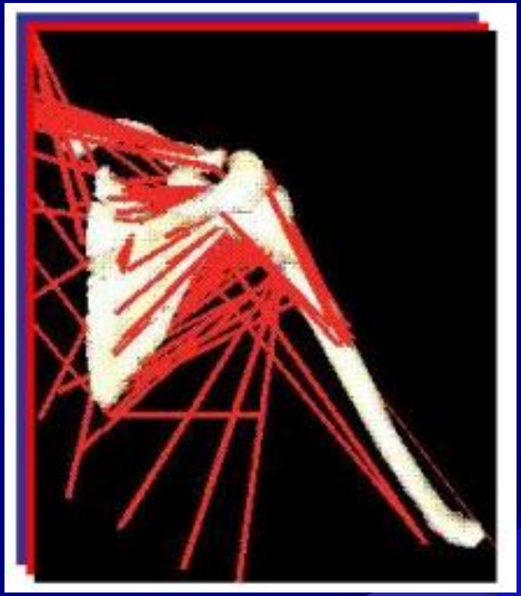
Network Model for Home-based Units

R3 Hypotheses

1. Combined intelligent stretching and voluntary movement training reduces ankle impairment in children with CP in terms of selected biomechanical and functional measures
2. Home-based rehabilitation in patients with CP will be more effective than lab-based rehabilitation in reducing ankle impairment with improved motor control in terms of the biomechanical and functional measures

R4: Advanced Mobility Modeling to Improve Function and Longer Term Transitional Care of Children with Orthopedic Disabilities

- Co-PI's
  - Brooke Slavens, Ph.D.
  - Gerald Harris, Ph.D., P.E.
- Patient population
  - Cerebral Palsy (CP): 12
  - Myelomenginocele (MM): 12
  - Spinal Cord Injury (SCI): 12
  - Osteogenesis Imperfecta (OI): 12
  - Pes Planovalgus: 20

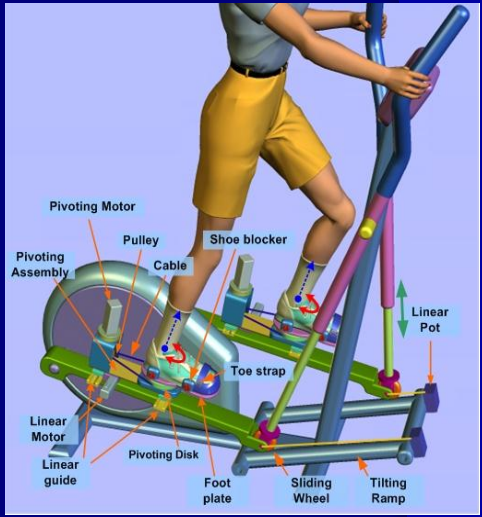


R4 Hypotheses

1. Proximal upper extremity joint demands are significantly greater than distal joint demands during assisted mobility in children using walkers, crutches and wheelchairs
2. Lower extremity joint demands (hip, knee, talocrural, and subtalar) in children with pes planovalgus are significantly reduced following subtalar arthroereisis

D1: Elliptical System to Improve Off-Axis Neuromuscular Control in Children with Orthopaedic Disabilities

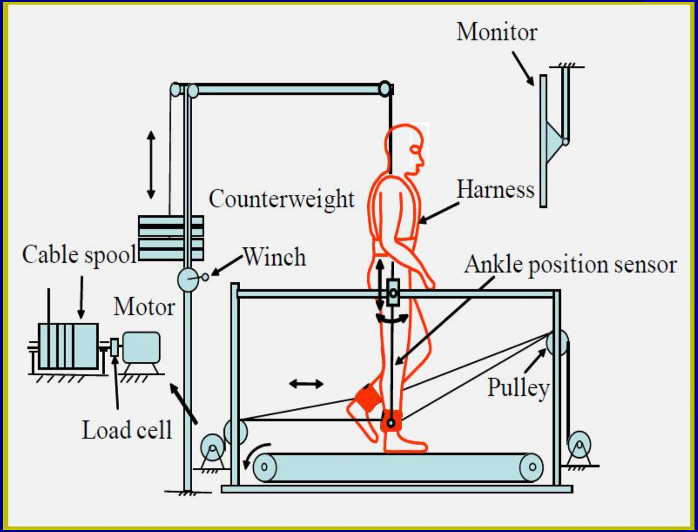
- Co-PI's
  - Yupeng Ren, M.S.
  - Li-Qun Zhang, Ph.D.
- Patient population
  - Cerebral Palsy (CP): 18
  - Patello-femoral Pain Syndrome: 18
- Project goal
  - Develop novel off-axis rehabilitation system to train children with severe orthopaedic disabilities



D1 Specific Aims

1. To design the ***pivoting and sliding elliptical rehabilitation system*** with integrated motivating ***biofeedback training games*** for children with orthopedic disabilities
   a. System will follow children during running/walking activities in sagittal plane
   b. Optional assistance and off-axis pivoting-sliding (training) motions in the frontal and transverse planes
   c. Guide users to improve neuromuscular control about the off-axes
   d. Obtain quantitative measurements
   e. Developed off-axis virtual reality games will further motivate children for more active involvement in the training
2. To evaluate the off-axis training system and resulting neuromuscular control changes in terms of stability, strength, stiffness, proprioception, and reaction time in tibial rotation and mediolateral sliding
   a. Employ a “design-build-test-design” strategy
   b. Evaluation/quality control paradigm
   c. Clinical use and further commercialization

D2: 3D Pediatric Robotic Gait Training to Improve Locomotor Function in Children with CP



- PI
  - Ming Wu, Ph.D.
- Patient population
  - Cerebral Palsy (CP): 30
- Project goal
  - Develop 3D robotic gait training system
  - Apply controlled forces in sagittal and frontal planes & allow natural 3D stepping motion

D2 Specific Aims

1. Development of 3D robotic gait training system that applies controlled forces to both sagittal and frontal planes during treadmill training
   a. Develop 3D cable driven robotic gait training system that applies synchronized forces to both the pelvis and legs during treadmill training
   b. Develop child-friendly biofeedback system to improve active involvement of children with CP during training sessions
2. Improve locomotor function in children with CP through 3D robotic BWSTT
   a. Test improvements of locomotor function in children with CP through 3D robotic gait training that applies controlled forces to both pelvis and legs
   b. Compare training effect of the 3D robotic BWSTT vs. BWSTT alone

D3: Biplanar Fluoroscopic System for Dynamic, *in vivo* Foot and Ankle Motion Analysis

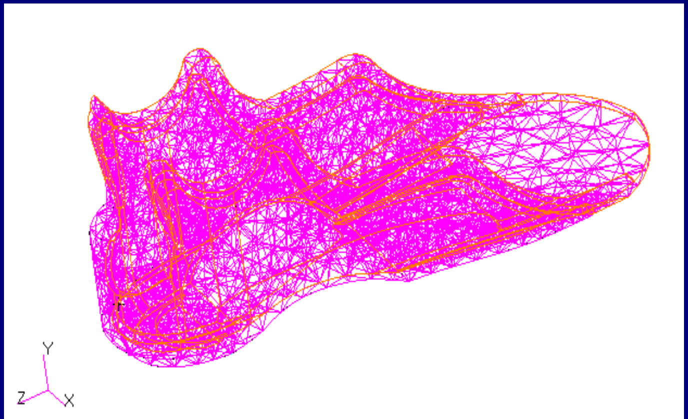
- PI
  - Taly Gilat Schmidt, Ph.D.
- Patient population
  - Other: 5 (children aged 10 – 18 yrs.)
- Project goal
  - Develop a biplane x-ray fluoroscopy system for analyzing *in vivo* motion of the bare or shod foot

D3 Specific Aim

- To develop a prototype biplane fluoroscopy system and manual feature extraction method for in vivo studies of subtalar hindfoot kinematics

D4: 3D Fluoroscopy and Pressure Validated Orthotics in the Application of Pediatric Flatfoot

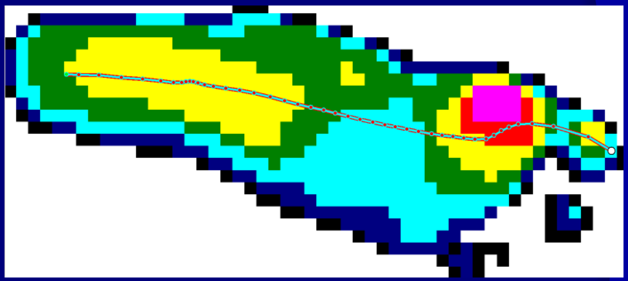
- Co-PI's
  - X.C. Liu, Ph.D.
  - R. Rizza, Ph.D.
- Patient population
  - Pes Planovalgus: 3



- Project goal
  - Develop new orthotic based on 3D foot geometry below the malleolis, dynamic plantar and lateral-medial pressure during walking and validated by 3D calcaneous-talus orientation measured using 3D fluoroscopy

D4 Specific Aims

1. Develop a trio-pressure measurement technique for plantar and lateral calcaneus and medial talar head
2. Validate computer aided design and FE model for new design of orthosis using a 3D fluoroscopy kinematic model and kinetic data
3. Establish effective procedure to manufacture dynamic orthosis for children with flexible flatfoot using a Rapid Prototyping System (RPS)



Trio-pressure measurements for flatfoot: a medial shift of plantar pressure distribution at the midfoot and forefoot

8 Training Activities

1. *Advanced Rehabilitation Research Training Fellowships (ARRTs)*
2. *Graduate Assistantships (RAs)*
3. *Online Training Course*
4. *Senior Design Projects*
5. *ATAD (Assistive Technology & Accessible Design) Certificate, University of Wisconsin-Milwaukee*
6. *RERC Teaching Modules*
7. *Summer Internships*
8. *Training Events – State-of-the-Science Conference*

Training Populations

Training Activity	Target Population			Number of Trainees				
	Res	Prac	Cons	Y1	Y2	Y3	Y4	Y5
T1: ARRT Fellowships	x	x		2	2	2	2	2
T2: Research Assistantships	x			10	10	8	7	7
T3: Online Training Course	x	x		30	50	70	90	110
T4: Senior Design:	x			2	2	2	2	2
T5: ATAD Certificate		x		1	1	1	1	1
T6: RERC Teaching Module (c = curricula)	x	x	x	1c	3c	5c	7c	9c
T7: Summer Internships	x	x		5	5	5	5	5
T8: State-of-the-Science Conference & Workshops	x	x	x	50	50	100	50	50

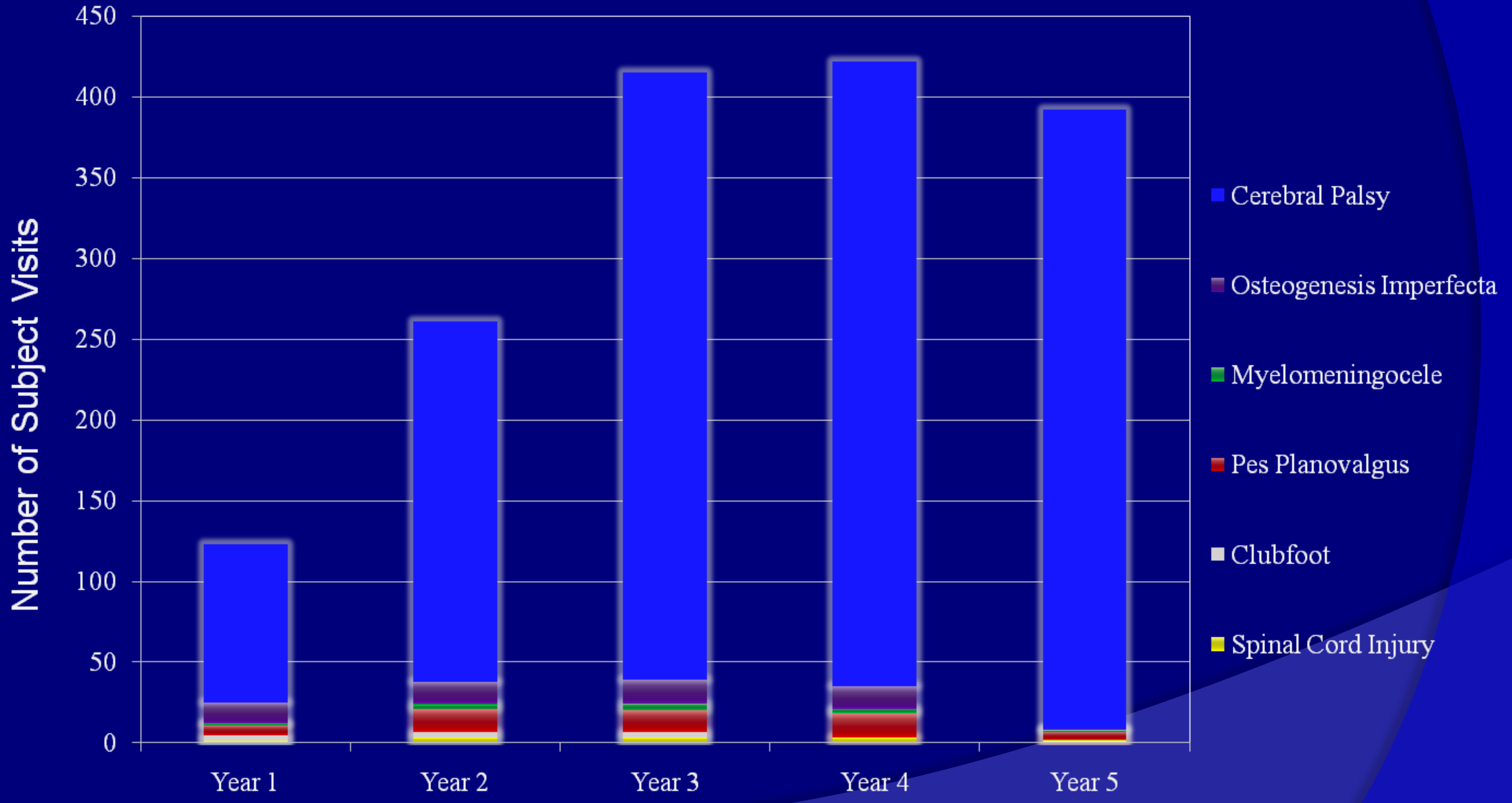
8 Dissemination Activities

1. *Publications, Accomplishments, Studies and Devices/Prototypes*
2. *Information Response and Referral/Technical Assistance*
3. *Primary RERC Website*
4. *Resources Component of the Website*
5. *Conference Presentations*
6. *Link to NCDDR/NARIC/SEDL/KT4TT*
7. *Accessibility*
8. *Technology Transfer*
   - *Plan revisions & updates, Impact assessement*

Dissemination

Dissemination Activity	Target Population			Timeline & Quantity				
	Res	Prac	Cons	Y1	Y2	Y3	Y4	Y5
DA1: Publications, Accomplishments, Studies and Devices (d=development; p=published)	x	x	x	d=4 p=2	d=6 p=4	d=8 p=6	d=8 p=8	d=8 p=8
DA2: Information, Referral & Technical Assistance	x	x	x	10	20	30	40	50
DA3: Website - RERC Primary Site	x	x	x	xx	x	xx	x	xx
DA4: Website - Resources	x	x	x	20	40	60	100	180
DA5: Conferences	x	x		1	2	2	2	3
DA6: NCDDR/NARIC/SEDL/KT4TT		x	x	x	x	x	x	x
DA7: Accessibility	x	x	x	x	x	x	x	x
TT1: Technology Transfer - Revise Plan	x	x	x	x				
TT2: Technology Transfer - Early	x	x		2	2	2	2	1
TT3: Technology Transfer - Impact		x	x	0	1	2	4	4

RERC: Overall Impact on Children with Orthopaedic Disabilities



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