Emerging UE Assessment and Intervention Strategies for Pediatric Musculoskeletal Conditions

Susan V Duff, EdD, PT, OT/L, CHT, ¹,² Dorit H Aaron, MA, OTR, CHT, FAOTA, ²
Gloria Gogola, MD ²
¹Chapman University, ²Shriners Hospitals for Children

OBJECTIVES
1. Discuss the unique needs of the pediatric population with regard to examination and treatment of upper limb musculoskeletal disorders.
2. Identify innovative outcome measures designed to assess shoulder biomechanics, dexterity, and interlimb coordination.
3. Describe novel, evidence-based interventions to promote increased upper limb muscle activation and capacity for prehensile tasks.

I. Unique considerations in pediatrics

A. Developmental Factors
   1. Non-linear progression – Rate limiting factors (Thelen, et al., 1993)
   2. Typical prehensile development
   3. Zone of proximal development (Exner, 2008; Vygotsky, 1978)
   4. Discriminating b/w normal development & change with intervention

B. Adult tests not standardized for children – yet often used!

C. Common pediatric musculoskeletal disorders
   1. Congenital Differences
      a. Radial Club Hand – s/p centralization of ulna
      b. Absent Thumb - s/p pollicization
      c. Amputations and other i.e., syndactyly, trigger thumb
   2. Arthrogryposis
   3. Peripheral nerve injury. i.e., brachial plexus injury
   4. Spinal cord injury
   5. Hemiparesis

II. Evaluation / Assessment within ICF

A. Participation – COPM (Law et al., 2005), CAPE (King et al., 2004), interview

B. Activity
   1. Observation of self-care, play, and recreational activities
      a. Hand preference or handedness
      b. Typical hand use: Prehension /MACS (Eliasson et al., 2006)
2. Dexterity tests
   a. Box and Block Test *(Mathiowetz, 1986)*
   b. 9-Hole Peg Test *(Pool 2005, Pont 2008)*
   c. Functional Dexterity Test *(FDT)*
   d. In-hand manipulation *(Exner, 1993, Pont et al., 2008)*
   e. Strength-Dexterity Test *(Valero-Cuevas, 1993)*

3. Bimanual / Interlimb Coordination
   a. Assisting Hand Assessment
   b. Everyday task performance
   c. Accelerometry - Inertial Sensors

C. Body, Structure & Function

1. Action ROM
2. Opposition
3. Hand and UE strength
   a. Manual muscle test
   b. Pinchmeter / Grip dynamometer
   c. Peg Restrained Intrinsic Muscle Evaluator *(PRIME)* *(Xu et al., 2011)*
      i. Intrinsic and hand strength *(Kozin et al., 1999)*
      ii. Research findings *(Xu et al., 2011)*

1. Shoulder Biomechanics *(Gharbaoui et al., 2015)*
   a. Scapulohumeral angle
      i. Inferior angle: scapulohumeral angle in abduction
      ii. Superior angle: scapulohumeral angle in adduction
      iii. Posterior angle: scapulohumeral angle in horizontal adduction
      iv. Glenohumeral internal rotational arc of motion
      v. Glenohumeral external rotational arc of motion
   b. Glenohumeral angles
      i. Internal rotation with arm in abduction
      ii. External rotation with arm in abduction
   c. Scapular dyskinesia
   d. Co-contractions
   e. Laboratory practice
      i. Stretching / muscle activation
      ii. Taping
      iii. Jacket
II. Development of the Functional Dexterity Test (FDT) for Children


1. 16 cylindrical pegs – 20 cm by 20 cm pegboard
2. Timed test (in seconds): pick-up each peg, turn over in air, and re-insert it

B. Pediatric design (Tissue et al., 2016)

1. Conversion to Speed is modification of the original methodology
   a. Speed (pegs/second) = 16/Time (sec)
   b. Benefits of using speed instead of time
      i. Speed vs. age becomes linear for both children and adults
      ii. Speed differences: Dom vs ND hand - constant across age
      iii. Children who can't complete entire board can be scored on partial completion by timing for number of pegs completed

2. Standardization results: FDT with Children
   a. 175 children (age range 4 to 17 years); 88 females & 87 males
   b. 89.1% of children right-handed
   c. Children's speed increased linearly at 0.04 pegs/s per year of age
   d. Dexterity can be modeled by this regression equation:
      Speed (pps) = 0.04 x Age (yrs) + 0.09 (Dom hand); R^2 = 66.0%
      i. Children's speed predicted from regression formula of others based on age & hand dominance; gender ns
      ii. Pedi Dexterity Growth Chart

C. Other Research

2. Is the unaffected upper extremity in children with hemiplegic cerebral palsy truly unaffected? (Burn et al., 2016)
3. Do children with C5-C6 brachial plexus palsies have normal hand function? (Bernstein and Gogola 2017 in review)

D. Conclusion about the FDT

1. Dominant hand faster at all ages; adult men faster
2. FDT- can evaluate effectiveness of surgery & change with therapy
3. FDT provides us with a “dexterity growth chart”
4. For children: expected speed best predicted from norms (growth chart)
5. For adults: expected speed is best predicted by testing unaffected hand & adjusting for hand dominance
E. Laboratory practice

III. Intervention

A. Muscle activation using SEMG and the contingent reinforcement paradigm

1. Contingent reinforcement paradigm – sample reinforcement
2. Populations: PBPI, SCI, Muscular Dystrophy
3. Findings from pilot work (Duff et al., in press)

B. 3D printing of prosthetic hands (Burn and Gogola, 2016)

1. Background: old and new prosthetic guidelines
2. Pediatric considerations
3. Acceptance/rejection of prosthesis (Davids, 2006; Postema, 1999)
4. Future trends
   a. DARPA
   b. 3-D printed hands (Gretsch et al., 2015)

5. Demonstration

IV. Discussion of Usefulness and Implementation

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