INSTRUMENTED MOTION ANALYSIS COMPARED WITH TRADITIONAL PHYSICAL EXAMINATION AND VISUAL OBSERVATION

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Objectives:
1) Summarize research comparing clinical evaluation and visual gait assessment to instrumented 3D gait analysis
2) Describe specific situations in which instrumented gait analysis is especially useful

CLINICAL EVALUATION & VISUAL GAIT ASSESSMENT

Relationship Between Clinical Evaluation and Dynamic Function

1. Poor correlation between static and dynamic joint ROM (McMulkin et al., 2000)
2. Cannot extrapolate passive ROM to dynamic function
   a. Children with hip flexion contracture often do not have excessive hip flexion during gait
      i. Weak association (r=0.41) between hip flexion contracture by Thomas test and peak hip extension during gait (Lee et al., 1997)
      ii. Half of children with >10° passive hip flexion contracture by Thomas test do not have excessive hip flexion in terminal stance (Rethlefsen et al., 2010)
   b. Tight plantarflexors can stretch under dynamic loading
   c. Popliteal angle does not indicate dynamic hamstring length during gait (Thompson et al., 2001)
3. Dynamic function depends on more than isometric muscle strength (Dallmeijer et al., 2011)
   a. Ankle moment during walking far exceeds moment generated by isometric plantarflexion.
      i. Children with CP have 90% reduction in plantarflexor strength compared with typical, but ankle moment during gait is only reduced 20%, power is reduced 40%
Visual Versus Instrumented Gait Analysis

1. Observational gait scales provide structure for visual gait assessment
   a. Multiple scales have been developed
      i. Physician Rating Scale (Corry et al., 1998; Koman et al., 1993)
      1. Observational Gait Scale (Boyd & Graham)
      2. Visual Gait Assessment Scale (Dickens and Smith, 2006)
      3. Video Gait Analysis (Ubhi et al., 2000)
      ii. Edinburgh Visual Gait Score (Read et al., 2003)
      iii. Salford Gait Tool (Toro et al., 2007a)
   b. Usually utilize split-screen biplanar video (front/back and side views) which can be viewed in slow motion or frame-by-frame
   c. Typically semi-quantitative, often using scores based on ranges of joint angles

2. Intra- and Inter-Observer Reliability
   a. Studies have generally shown reasonable intra- and inter-rater reliability (Dickens and Smith, 2006; Kawamura et al., 2007; Mackey et al., 2003; Read et al., 2003; Toro et al., 2007b; Viehweger et al., 2010; Wren et al., 2005) although one study reported excellent reliability within, but poor reliability between observers (Maathuis et al., 2005)
   b. Experienced observers are more reliable than inexperienced observers (Brown et al., 2008; Maathuis et al., 2005; Viehweger et al., 2010)
   c. Use of slow motion video can improve reliability, particularly at the knee and ankle (Wren et al., 2005)
   d. Reliability decreases proximally such that reliability is good at the foot and ankle but poor at the hip, pelvis, and trunk (Brown et al., 2008; Dickens and Smith, 2006; Read et al., 2003; Viehweger et al., 2010; Wren et al., 2005). Reliability at the knee is variable.

3. Accuracy / Validity
   a. Evaluated through comparison with 3DGA
   b. Some studies indicate moderate to good (58-64%) accuracy of visual assessment of joint angles (Mackey et al., 2003; Read et al., 2003) while others indicate poor accuracy (Dickens and Smith, 2006; Kawamura et al., 2007; Wren et al., 2005)
   c. Experienced observers are more accurate (Brown et al., 2008). Inexperienced observers have poor accuracy; accuracy of experienced observers is variable (Mackey et al., 2003).
   d. Use of slow motion video improves accuracy for foot contact, ankle, and knee but not hip (Wren et al., 2005)
   e. Accuracy is greatest for knee flexion/extension and pelvic obliquity (Kawamura et al., 2007; Wren et al., 2005)
   f. Ankle dorsiflexion is underestimated in visual assessment (Wren et al., 2005)
   g. Hip flexion is overestimated in visual assessment (Wren et al., 2005)
   h. Visual assessment is most accurate for extreme cases or when joint angles are clearly normal. The greatest inaccuracy occurs for borderline measurements,
when accurate assessment is most critical for clinical decision making. (Wren et al., 2005)

SPECIFIC APPLICATIONS OF COMPUTERIZED GAIT ANALYSIS

1. Transverse plane problems: intoeing, out-toeing
   a. Often multiple causes of intoeing (Rethlefsen et al., 2006)
      i. Most often internal hip rotation/femoral anteversion and/or internal tibial torsion
      ii. Pes varus is a frequent cause in unilaterally involved patients, rare in bilaterally involved subjects
      iii. Pelvic rotation, metatarsus adductus also contribute in many cases
   b. Poor correlation between static measures of femoral anteversion and hip rotation and foot progression measured with gait analysis (Aktas et al., 2000; Carriero et al., 2009; Radler et al., 2010)
   c. Multiple causes of out-toeing
      i. External tibial torsion
      ii. External hip rotation
      iii. Pes valgus
   d. Case example of above – video vs. gait analysis data

2. Varus feet in patients with CP
   a. Only dynamic EMG can identify cause(s) (Michlitsch et al., 2006; Scott and Scarborough, 2006)
      i. Posterior tibialis (PT)
      ii. Anterior tibialis (AT)
      iii. Both AT and PT
      iv. Bony deformities
      v. Other muscle imbalances (tight gastrocsoleus, peroneal weakness)
   b. Case example of above – video vs. EMG

3. Valgus thrust at the knee in myelomeningocele
   a. Only kinematics and kinetics can determine if actual valgus or “visual valgus”
      i. True knee valgus thrust is more common in patients with greater levels of disability
      ii. Associated with hip abductor weakness and compensatory excessive trunk lateral lean during gait (Gupta et al., 2005; Ounpuu et al., 2000)
      iii. Visual assessments are inaccurate, often underestimate true valgus thrust
         1. Visual valgus likely reflects combined internal hip/pelvic rotation, hip/knee flexion, and external rotation of the lower leg
   b. Case example of above – video vs. kinematics and kinetics

REFERENCES


