Upper limb movements

Introduction

The study of upper limb movements has a long history...
Upper limb movements are fundamental for daily living activities.

The study of upper limb movements not only is important in the clinical field, but also has an important role in the characterization of specific tasks in healthy subjects.
There is a wide range of pathologies with consequences on functional limitation of upper limb movements:

- Cerebral Palsy
- Multiple Sclerosis
- Parkinson's disease
- Spino-cerebellar lesions
- ...

Brief description of upper limbs
Upper limbs

Upper extremity.—The disposition and structure of the bones of the upper extremity afford a marked contrast to those of the lower. The latter are organs of support, and therefore are solid, firm, strong, and, withal, elastic. The former are destined to perform extended motions, as well as minute and nicely adjusted ones; and, therefore, while they possess all the requisite strength, they are light, present little expanse of surface, and are articulated by numerous very moveable articulations.

Robert Bentley Todd, Sir William Bowman, 1857, The Physiological Anatomy and Physiology of Man

Muscular apparatus

Muscles of the upper limb
Bones of upper limbs

- Clavicle
- Scapula
- Humerus
- Radius
- Ulna
- Carpus
- Metacarpus
- Phalanges

Shoulder joint

Upper arm flexion/extension
Upper arm abduct/adduction

Sterno-clavicular movement:
Elbow joint

Potential model

Ball and socket joint

Rotating hinge joints
Quantitative analysis of upper limb movements

Gait Analysis: main aspects

- Gait Analysis
- Well defined movement
- Repeatable movement
- "Limited" movement
- Cyclic movement

Development and Use of Standard Protocols
Upper limb: main aspects

- Upper limb
- Unavailable standard movement
- Repeatable movement?
- It is difficult to transfer concepts from gait analysis to upper limb movements

LACK OF STANDARD PROTOCOLS

Experimental setup

1) Choice of a movement

2) Marker and EMG placement, related to pathology and deficiencies

3) Choice of variable of interest for the considered pathology

The choice of experimental setup is based on pathology and variables of interest
The choice of experimental setup is related to considered pathology

Reaching

Hand to mouth

Grasping

Finger

The choice of the experimental protocol is influenced by pathology, analyzed movement and variables of interest.

Recruitment and sequencing of different degrees of freedom during pointing movements involving the trunk in healthy and hemiparetic subjects

Pediatric Research Vol. 57, No. 4, 2005
Kinematic Characteristics of Reaching Movements in Preterm Children with Cerebral Palsy

Arch Phys Med Rehabil Vol. 81, February 2000
Deficits in Upper-Limb Task Performance in Children With Hemiplegic Cerebral Palsy as Defined by 3-Dimensional Kinematics
Many parameters can be computed and they are strictly related to analyzed movement, marker set, and biomechanical model.

The aim is the functional characterization of movement: quantify functional limitation, highlight motor synergies, focus on motor control, ...

**Angles**

**Trajectories**

Elbow flex/ext: morphology, velocity, peaks, ...

Elbow flex/ext, shoulder angles, trunk angles: velocity, range of motion, ...

Elbow flex/ext, shoulder angles: velocity, acceleration, frequency analysis, ...
Experimental protocol

**Movement time, initial direction, velocity peaks, ...**

**Movement time, index of curvature, number of movement units, ...**

**Number of movement units, normalized Jerk:**

\[
NJS = \sqrt{\frac{3}{2} \int (\gamma^2 \cdot \dot{\gamma}^2 + \dot{\gamma}^2)^2}
\]

**Velocity profiles, grasp aperture, ...**

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**Kinematic Characteristics of Reaching Movements in Preterm Children with Cerebral Palsy**

JHANNA C. VAN DER MECH, JOHANNA M. ROEL, PETER HOFF, ELISABETH TREDANO, AND MARIA SANTINA ALDANA

Kinematical measure for spastic reaching in children with cerebral palsy

Jhy-Jong Chang 
Tung-I Wu 
Wen-Lan Wu 
Fung-Chin Su

**Experimental protocol**